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COMPILATION OF SHOCK AND VIBRATION FLIGHT DATA FROM EIGHT THOR-RELATED VEHICLES

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ABSTRACT

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This report presents a compilation of shock and vibration data measured on eight Thor-related vehicles. These dynamic data are in the form of acceleration spectral densities, composite G_{rms} time histories, and peak accelerations for prominent sinusoids. In addition, there are descriptions of the flight vehicles, tabulations of trajectory data as functions of time, descriptions of the transducers and their locations and mounting structures, descriptions of the telemetry equipment and channels and of the data reduction process.

Since the purpose of this report is only to report actual flight vibration and shock data, no discussion and interpretation of data or test results are included. All data is presented in tabular or graphical form.

Author

Descriptors: vibration, acceleration, shock, Thor, Delta, Agena, Asset, trajectory, instrumentation

PREFACE

This report was prepared by the Vibration, Shock & Acoustics Section of Douglas Aircraft Company, Inc., Missile & Space Systems Division, for the NASA, Langley Research Center, under Contract No. NAS1-4329. This report fulfills all the requirements of this contract. The organization and general contents of the report are compatible with those suggested by the NASA in their Invitation for Bid L4292.

The preparation of this report was accomplished during the period October-November, 1964.

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I. INTRODUCTION

The Douglas Aircraft Company, Inc. (DAC) has acquired shock and vibration data on a total of 53 Thor and Thor-related flight vehicles. Most of these data have been reduced from magnetic tape, analyzed, and documented in report format for the contracting agencies. However, flight vibration data obtained from eight Thor-related vehicles have not been documented in report format since these data to date have been used solely by DAC for comparison with design criteria.

This report presents the shock and vibration flight data obtained from these eight Thor-related vehicles. Included with these flight data are descriptions of the flight vehicles, tabulations of trajectory data as functions of time, descriptions of the transducers and of their mounting structures, and descriptions of the data acquisition and reduction system. The flight vibration data are presented in the form of time histories of composite G_{rms} vibration levels, acceleration spectral density analyses, and peak accelerations (g o-peak) of prominent sinusoids. No analyses or interpretations of the data are presented, since they were not the objective of this contract.

II. FLIGHT VEHICLE

The eight Thor-related vehicles discussed in this report include two Thor/Agenas (boosters. S/N 353 and 365), a Thor/Asset (booster S/N 232), two Thor/Delta/Assets (boosters, S/N 240 and 250), and three vehicles designated only as DSV-2J (S/N 20002, 20003, and 20006). Figures 1, 2, 3, and 5, respectively, show these vehicle configurations.

All of these vehicles employed for their booster stage either the basic Thor booster (DSV-2A) or some modification of this configuration. The Thor/Agenas employed a DSV-2A configuration Thor booster, which utilizes a (Rocketdyne MB-3 Block II) main engine having a nominal thrust of 170,000 lbs. The Thor/Asset employed a DSV-2F booster configuration, which features a .125 inch aluminum doubler over the .063 inch aluminum skin covering the guidance section, and includes other minor structural variations upon the basic Thor booster. The DSV-2F booster employs a

Rocketdyne MB-3 Block I main engine with a nominal thrust of 150,000 lbs. The Thor/Delta/Assets employed a DSV-2G configuration booster, which embodies a number of minor structural changes over the basic Thor booster; these modifications, however, do not affect the measured vibration data relative to other Thor vehicles. The DSV-2G booster utilizes a Rocketdyne MB-3 Block II main engine with a 170,000 lb thrust. The DSV-2J vehicles employed a DSV-2J configuration Thor booster, which has an extended guidance section structure. This booster utilizes a Rocketdyne MB-3 Block I main engine with a nominal thrust of 150,000 lbs.

The Thor/Agena and Thor/Delta/Asset vehicles also employed a second stage, which had its own propulsion system and guidance system. The second stage of the Thor/Agena was the Lockheed-built Agena D vehicle, with a nominal thrust of approximately 15,000 lbs and weight of approximately 17,300 lbs. The second stage of the Thor/Delta/Asset was the Douglas-built Delta vehicle, with a nominal thrust of 7,500 lbs and a weight of 6,100 lbs.

The Asset payload of the Thor/Asset and Thor/Delta/Asset vehicles is a McDonnell-built, winged, re-entry vehicle having a high lift-to-drag ratio. The payloads of the DSV-2J vehicles and of the Thor/Agena vehicles are classified.

III. FLIGHT TRAJECTORY DATA

Actual flight trajectory data were determined for all the vehicles for the time period from liftoff through main engine cutoff (MECO). The specific parameters of vehicle weight, mach number, dynamic pressure, altitude, fuel weight, and oxidizer weight were recorded as a function of time (in 10-second increments) and are presented in Tables 1 through 8. The two Thor/Delta/Asset vehicles were instrumented to obtain environmental data also during second stage flight. Due to a malfunction at separation from the booster, no data were obtained from one vehicle (booster S/N 240); the data obtained during second stage flight of the other vehicle (booster S/N 250), however, were obtained. Therefore, flight trajectory data for this vehicle were determined for second stage flight also and are included in Table 8.

IV. INSTRUMENTATION

A. Transducers

Piezoelectric and strain gage type accelerometers were both employed to acquire shock and vibration data. Specific characteristics of the transducers and associated amplifiers are tabulated in Table 9.

It should be noted that the accelerometers were mounted at locations where they would measure input vibration levels to critical equipment and, in one instance, to the payload. As indicated in Table 10, these locations included (1) the bracket supporting the flight controller, (2) the bracket supporting the BTL-600 guidance unit (as noted in Table 10, the BTL-600 guidance unit was mounted in the second stage of the two Thor/Delta/Asset vehicles), (3) a stringer to which the distribution box was attached, and (4) a cross beam located at interface of the Asset vehicle and the adapter beneath it. The data measured at this latter location were obtained by McDonnell Aircraft Company to determine the low frequency vibration loads transmitted to the Asset vehicle along the longitudinal axis.

Table 10 presents the resonance frequencies and amplification factors of the structure upon which these transducers were mounted. These resonance frequencies and amplification factors were obtained from several ground vibration tests. Figures 1 through 5 present illustrations of the accelerometer locations and also detailed views of the accelerometer mountings.

B. Telemetry

Vibration data were transmitted from the launch vehicle to ground receiving stations via FM/FM telemetering systems. The subcarrier oscillator bands conformed to IRIG standards. Table 11 defines the subcarrier center frequency and percent deviation utilized, and also the nominal intelligible upper frequency limit (cutoff frequency) for each channel. Based on a series of tests conducted by Douglas it is concluded that the rolloff at the cutoff frequency is as follows:

Subcarrier Center Frequency (KC)		Total Rolloff (db)	Upper Frequency Limit (cps)
40	$\pm 15\%$	3	1200
22	$\pm 15\%$	5	660
14.5	$\pm 7.5\%$	5	220
10.5	$\pm 7.5\%$	3	160

It should be noted that the total rolloff derives from two sources: the low pass (Gaussian) filters in the data playback system (Figure 6) and the characteristics of the subcarrier oscillators in the telemetry system (Figure 7). It is known that the rolloff due to the Gaussian filters is 3 db at the cutoff frequency.

The data acquisition system was not calibrated above the upper cutoff frequency of the respective telemetry channel; therefore, data that are beyond this frequency are not meaningful. The noise level of the telemetry was determined to be approximately 4% of the full-scale setting of each channel.

C. Ground Receiving System

Telemetry flight data from the eight vehicles were recorded at three different ground stations depending on the launch site. Ground receiving tape recorders (see Table 12) at each station were comparable in performance, meeting IRIG standards for FM/FM recorded signals. The tape recorders had a frequency response characteristic that was flat ($\pm$ 1/2 db) throughout the entire frequency frange from 0 cps to approximately 100,000 cps. The noise floor of the tape recorder was less than 1% of full scale setting of each channel.

V. DATA

A. Analysis

The vibration data required from the eight Thor-related vehicles were characteristically of a random, sinusoidal, and transient acceleration nature. These data are presented in this report in either graphic or tabular form. Time histories of G_{rms} vibration for all eight vehicles at one or more accelerometer locations are presented in Figures 8 through 18. Discrete sinusoids of interest for each vehicle have been tabulated in Table 13. Acceleration spectral density analyses of important and characteristic steady-state vibration periods are presented in Figures 19 through 27. These vibration periods include liftoff, subsonic flight, transonic flight, periods of peak vibration, Mach 1, maximum dynamic pressure, and supersonic flight. Figure 7 presents a schematic of the data reduction system used in obtaining the vibration time histories and acceleration spectral density analyses.

The transient accelerations associated with each flight are produced by the cutoff of the Thor booster's main engine. Spectral analyses of transient accelerations are ordinarily reduced in shock spectra format. However, for these eight vehicles, shock spectra analyses were not performed. Both spectral characteristics and peak accelerations for this flight condition have been established from flight data previously recorded on other Thor vehicles and have been documented in the reference reports in Appendix I. Composite shock levels, however, can be determined from the time histories of the flight data, which are presented in graphic form for each of the eight vehicles.

The sinusoidal vibrations observed on the eight vehicles were produced by transient and oscillatory phenomena associated with the Thor booster. Peak levels and frequency characteristics of the sinusoids are presented in Table 13. Low frequency sinusoids below 30 cps were determined by filtering the composite signal through 45-cps low pass filters and recording the filtered signal on a high speed oscillograph.

The presence of multiple sinusoids were determined from the wave-shape of the filtered signals. For multiple sinusoidal signals, narrow band spectral analyses in 1- and 2-cps bandwidths were digitally performed to identify the sinusoidal frequencies. The sinusoids were subsequently reduced through both a 45-cps low pass filter and Bruel and Kjaer wave analyzer, and then recorded on an oscillograph. Calibration signals were also reproduced through the same data reduction equipment to establish insertion loss and frequency response characteristics of the data reduction system, for use in establishing corrections for the sinusoidal signals. The high frequency sinusoids were established from a one-third octave band analyses of the flight data. Output signals were recorded on an oscillograph.

In obtaining the acceleration spectral density analyses, stationary vibration periods were selected. The filtered information from the discriminator was passed through an analog-to-digital converter and the digitized data fed into an IBM 7094 computer. Table 12 presents the specific equipment models used by Douglas in its data reduction system. The Douglas computer program used in the analysis of stationary vibration data is called TD60. The TD60 analysis program contains three separate programs: the acceleration spectral density analysis, the amplitude distribution, and the cross spectrum.

The acceleration spectral density analysis produces a plot of the parameter-squared-per-unit-bandwidth versus frequency by Fourier cosine transformation of the auto-correlation function of the particular stationary parameter being analyzed. All computed acceleration spectral density values are converted to a decibel scale and are printed as such on the tabulation with the corresponding frequencies. A tape output is available for automatic x-y plotting using an SC 4020 recorder.

The maximum dynamic range of analysis is approximately 40 decibels. Resolution and accuracy are traded off according to the relationship

$$E^2 = \frac{200}{fT}$$

where

E is the width of the 90% confidence interval in decibels

Δf is the resolution in cps (the analysis will resolve peak Δf apart)

T is the sample duration in seconds.

The maximum number of input data points at the present time is 20,000. A maximum number of 1,000 acceleration spectral density values may be computed.

B. Accuracy and Validity of the Data

The flight data accuracies are based on signal degradation from components which constitute the data acquisition and data reduction system. Probable errors associated with each data presentation (G_{rms} vs time, peak sinusoidal levels, and acceleration spectral density analyses) were computed from test data acquired for representative shock and vibration data systems. The probable error associated with the composite vibration time histories (G_{rms}) is ± 2.2 dB ($\pm 28\%$). The accuracy of the acceleration spectral density analysis for random vibration data, as previously shown, is a function of data sample numbers of digital points used, etc. In general, these analyses are accurate based on a 90% confidence level to ± 1.5 dB. Therefore, the probable error associated with the acceleration spectral density analysis is ± 1.8 dB ($\pm 20\%$). The probable error of the discrete sinusoidal vibration levels is also ± 1.8 dB ($\pm 20\%$).

The Acceleration Spectral Density Analyses for the DSV-2J flights were produced using a resolution of 10 cps. All of the other acceleration spectral density analyses used a resolution of 20 cps. Consequently, the DSV-2J acceleration spectral density analyses are invalid below 10 cps, and all the other acceleration spectral density analyses are invalid below 20 cps.

It should be pointed out that the spectrum shapes of several acceleration spectral density analysis (Figures 20b, 20d, 26a, 26b, and 26c) appear unusual in that the peak spectral level occurs at very low frequency. An extensive study of these reduced data have been made and to date these data cannot be shown to be in error. However, use of this information should be tempered with the knowledge that these data do not typify the characteristics of Thor structural response, as can be seen by reviewing other spectrum plots presented in this report.

All of the data presented in this report is considered to be valid (i.e., of good quality). Unreliable data (i.e., data exhibiting (1) excessive preflight and/or inflight noise and/or (2) distorted wave form, etc.) have not been included in this report.

Of the data included in this report, the following statements can be made.

Vehicle No. and Channel	Remarks
DSV-2J No. 20002 (radial vibration)	Data on this channel are of good quality throughout flight. Although bandedge levels are exceeded by a factor of about 10% during liftoff and transonic flight, there is no indication of distortion in the acceleration density spectra.
DSV-2J No. 20006 (radial vibration, thrust vibration)	Both channels are of good quality throughout flight. Peak amplitudes never exceed bandedge levels.
DSV-2J No. 20003 (radial vibration)	Data on this channel are of good quality throughout flight.
Thor/Asset Booster S/N 232	All data are of good quality; however, at the Asset/Adapter interface the flight data was very low in level and was beneath the data acquisition system threshold noise level at all times except liftoff and Mach I.
Thor/Delta/Asset, Booster S/N 240	Data are of good quality at all times. However, telemetry dropout occurred at stage separation; consequently, there are no data after this event. All three of the Acceleration Spectral Density plots of data from the second stage appear unusual in spectrum.
Thor/Delta/Asset Booster S/N 250	Data are of good quality at all times except second stage (i.e., Delta) ignition. At this time the signal dropout occurs for about 1/2 second.
Thor/Agena, Booster S/N 353	Data are of good quality throughout flight.
Thor/Agena, Booster S/N 365	Data are of good quality throught flight.

APPENDIX

A BIBLIOGRAPHY OF FLIGHT VIBRATION REPORTS ON THOR AND THOR/RELATED VEHICLES

Summary of Measured Shock and Vibration Environments - LV-2A (DSV-2C) Booster -- S. R. Lane, Douglas Report SM-44942, January 1964.

Analysis of Shock and Vibration Data - DSV-3B Delta Vehicle Number 15 -- E. C. Meltzer, Douglas Technical Memorandum A2-860-K441-TM-3, April 1963.

Analysis of Shock and Vibration Data - DSV-3B Delta Vehicle Number 16 -- W. F. Arndt, Douglas Technical Memorandum A2-860-K441-TM-5, May 1963.

Analysis of Shock and Vibration Data - DSV-3B Delta Vehicle Number 17 -- W. F. Arndt, Douglas Technical Memorandum A2-860-K441-TM-6, June 1963.

Analysis of Shock and Vibration Data - DM-19 Delta Vehicle Number 9 -- E. C. Meltzer, Douglas Technical Memorandum A2-860-A326-TM-7, July 1963.

Analysis of Twenty-Cycle Vibration Data Measured on Four Delta Vehicles, DSV-3B Delta Vehicle Numbers 19, 20, 22, and 23 -- W. F. Arndt, Douglas Report SM-45183, July 1964.

Study of Thor Vibration Study -- D. G. Douglas, Space Technology Laboratories, Inc. Report STL/TR-59-0000-09922, December 1959.

TABLE I

TRAJECTORY DATA AS FUNCTIONS OF TIME

THOR/AGENA, BOOSTER S/N 353

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	122,811	0	0	183	32,048	67,779
10	116,270	0.11	19	780	29,918	63,219
20	109,532	0.26	91	2,855	27,763	58,549
30	102,744	0.45	238	6,776	25,603	53,839
40	95,926	0.70	459	12,862	23,538	49,129
50	89,094	1.03	719	21,338	21,373	44,429
60	82,259	1.46	907	32,318	19,208	39,755
70	75,428	2.03	907	45,954	17,038	35,075
80	68,609	2.67	694	62,455	14,863	30,435
90	61,806	3.30	415	81,942	12,683	25,835
100	55,026	4.05	222	104,149	10,503	21,285
110	48,274	4.82	111	129,249	8,418	16,800
120	41,558	5.69	51	158,265	6,233	12,370
130	34,888	7.23	25	190,795	4,043	7,995
140	28,283	9.87	9	229,048	1,843	3,705
147.8 (MECO)	23,270	13.05	3	262,274	0	0

TABLE II

TRAJECTORY DATA AS FUNCTIONS OF TIME

THOR/AGENA, BOOSTER S/N 365

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	123,800	0	0	213	32,521	67,774
10	117,342	0.11	17	767	30,333	63,304
20	110,689	0.25	83	2,702	28,123	58,724
30	103,987	0.43	216	6,374	26,023	54,084
40	97,254	0.67	427	12,068	23,893	49,414
50	90,507	0.99	685	20,034	21,863	44,754
60	83,758	1.39	873	30,374	19,728	40,104
70	77,012	1.92	926	43,042	17,588	35,504
80	70,277	2.55	774	58,077	15,548	30,954
90	63,558	3.29	529	76,659	13,400	26,434
100	56,862	4.02	305	95,618	11,238	21,954
110	50,194	4.72	171	117,453	9,078	17,524
120	43,562	5.58	89	142,394	6,913	13,144
130	36,976	6.68	46	170,239	4,743	8,744
140	30,452	8.70	23	201,742	2,568	4,294
149.7 (MECO)	24,182	11.76	9	236,173	385	0
158.7	24,108	12.86	1.6	269,344		

TABLE III

TRAJECTORY DATA AS FUNCTIONS OF TIME

DSV-2J NO. 20002

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	108,426	0	0.	13	30,333	68,184
10	102,292	0.111	18.054	602	28,473	63,874
20	96,157	0.273	101.892	2,789	26,603	59,544
30	90,022	0.473	260.053	7,042	24,743	55,209
40	83,885	0.697	447.506	13,404	22,885	50,884
50	77,753	0.991	630.343	22,664	21,030	46,579
60	71,623	1.372	727.724	34,689	19,175	42,304
70	65,495	1.881	653.805	50,219	17,317	38,054
80	59,373	2.358	380.402	69,535	15,457	33,824
90	53,256	2.920	189.250	93,730	13,592	29,604
100	47,145	3.535	74.133	124,111	11,717	25,394
110	41,039	4.236	25.328	162,056	9,837	21,204
120	34,940	5.773	1.195	208,599	7,947	17,024
130	28,861	8.612	0.036	266,097	6,037	12,854
140	22,794	9.629	0.001	336,921	4,107	8,714
150	16,734	6.942	0	425,346	2,137	4,604
157.9 (MECO)	11,954	6.604	0	510,120	520	990

TABLE IV

TRAJECTORY DATA AS FUNCTIONS OF TIME

DSV-2J NO. 20003

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	108,304	0	0	13	30,223	67,919
10	102,088	0.124	22.439	698	28,353	63,639
20	95,871	0.279	104.638	2971	26,473	59,289
30	89,654	0.476	261.935	7175	24,598	54,919
40	83,435	0.720	471.201	13725	22,728	50,549
50	77,221	1.029	670.388	23064	20,858	46,209
60	71,010	1.412	745.344	35502	18,988	41,889
70	64,800	1.949	659.980	51494	17,188	37,579
80	58,596	2.419	358.750	71818	15,243	33,279
90	52,396	2.988	164.827	97683	13,363	28,989
100	46,202	3.580	58.186	130427	11,478	24,709
110	40,015	4.335	18.382	171653	9,583	20,439
120	33,839	6.188	4.606	223171	7,673	16,179
130	27,673	8.905	0.257	287267	5,748	11,939
140	21,521	7.909	0.004	367500	3,798	7,719
149.7 (MECO)	15,562	6.171	0	465774	1,860	3,300

TABLE V

TRAJECTORY DATA AS FUNCTIONS OF TIME

DSV-2J, NO. 20006

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	108,581	0	0	13	30,469	67,906
10	102,157	0.107	16.535	589	28,519	63,556
20	95,733	0.284	108.308	2958	26,564	59,116
30	89,308	0.495	282.203	7345	24,619	54,636
40	82,882	0.774	531.771	14351	22,679	50,151
50	76,459	1.108	734.588	24455	20,739	45,671
60	70,040	1.537	795.286	37829	18,799	41,196
70	63,623	2.137	656.785	55085	16,854	36,731
80	57,211	2.592	319.403	77122	14,904	32,276
90	50,804	3.208	131.616	105418	12,949	27,826
100	44,404	3.825	43.458	141364	10,989	23,386
110	38,008	4.853	13.118	186867	9,019	18,956
120	31,620	7.212	2.271	243507	7,039	14,536
130	25,250	9.261	0.055	314439	5,039	10,136
140	18,894	6.870	0.001	403561	3,009	5,766
144.6 (MECO)	15,966	6.336	0	452510	2,015	3,510

TABLE VI

TRAJECTORY DATA AS FUNCTIONS OF TIME

THOR/ASSET, DSV-2F

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	107,855	0.004	0.030	33	30,362	67,761
10	102,017	0.102	15.319	592	28,642	63,761
20	96,178	0.231	72.798	2,443	26,837	59,696
30	90,339	0.396	189.990	5,872	25,067	55,626
40	84,498	0.604	364.340	11,188	23,302	51,546
50	78,660	0.896	601.771	18,730	21,542	46,460
60	72,823	1.280	819.690	28,760	19,782	43,391
70	66,988	1.773	899.578	41,290	18,017	39,326
80	61,160	2.411	788.297	56,381	16,252	35,276
90	55,339	3.042	517.380	74,196	14,482	31,236
100	49,523	3.734	304.177	94,745	12,707	27,206
110	43,714	4.524	157.355	117,413	10,927	23,191
120	37,914	5.390	88.351	140,749	9,137	19,201
130	32,126	6.479	55.883	163,151	7,327	15,226
140	26,353	8.101	43.897	182,038	5,507	11,286
150	20,956	10.394	43.377	195,242	3,657	7,386
160	14,856	13.411	57.053	201,052	1,777	3,536
165.3 (MECO)	11,817	15.499	73.597	201,896	770	970

TABLE VII

TRAJECTORY DATA AS FUNCTIONS OF TIME

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE (FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	111,104	0.005	0.038	33	30,873	67,710
10	105,031	0.119	20.570	671	29,000	63,510
20	98,928	0.264	95.436	2,761	27,110	59,250
30	92,824	0.441	231.151	6,584	25,230	54,980
40	86,722	0.673	428.324	12,431	23,350	50,705
50	80,624	0.984	666.474	20,564	21,470	46,435
60	74,528	1.344	806.356	30,984	19,595	42,165
70	68,432	1.877	880.311	43,431	17,715	37,915
80	62,345	2.618	823.193	58,115	15,835	33,675
90	56,263	3.366	581.971	75,021	13,945	29,455
100	50,188	4.131	454.981	93,396	12,050	25,255
110	44,120	4.982	238.170	112,122	10,145	21,075
120	38,059	5.992	166.300	129,921	8,230	16,905
130	32,009	7.219	131.530	145,682	6,290	12,765
140	25,972	8.802	121.855	158,558	4,340	8,655
150	19,954	11.005	133.317	168,394	2,360	4,885
158.7 (MECO)	14,460	13.566	158.148	175,226	580	1,090

TABLE VIII

TRAJECTORY DATA AS FUNCTIONS OF TIME

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 250

TIME (SECONDS)	VEHICLE WEIGHT (LBS)	MACH NO.	DYNAMIC PRESSURE (LBS/FT^2)	ALTITUDE FT)	FUEL REMAINING (LBS)	OXIDIZER REMAINING (LBS)
0	111,145	0.015	0.325	32	30,330	67,691
10	104,968	0.115	19.450	666	28,438	63,406
20	98,767	0.257	89.433	2,577	26,557	59,086
30	92,658	0.438	227.509	6,577	24,783	54,751
40	86,452	0.678	439.296	12,459	22,912	50,416
50	80,267	0.992	638.766	20,714	21,043	46,100
60	74,112	1.394	870.464	31,488	19,173	41,815
70	67,984	1.965	937.106	44,805	17,303	37,557
80	61,874	2.584	730.231	60,751	15,428	33,322
90	55,772	3.245	475.876	79,376	13,548	29,100
100	49,677	4.016	291.535	99,814	11,663	24,890
110	43,592	4.782	154.852	120,498	9,773	20,695
120	37,512	5.749	102.154	140,328	7,873	16,515
130	31,437	6.952	77.371	158,069	5,958	12,355
140	25,367	8.637	71.507	172,215	4,023	8,220
150	19,304	11.054	80.227	182,531	2,063	4,120
158.8 (MECO)	14,103	14.018	97.440	189,887	173	467
163 (Second Stage Start)		14.182	83.763	194,435	552	1,725
170		14.658	72.987	199,296	502	1,583
180		15.320	64.118	204,765	429	1,375
190		15.977	58.668	209,018	356	1,166
200		16.623	57.028	211,448	283	960
210		17.253	59.054	212,056	211	756
216.8		17.674	62.802	212,056	163	619

TABLE IX

TRANSDUCERS

Vehicle	Instrument*	Manufacturer and	Manufacturer Model No.	Douglas Part No.	Frequency Response (cps)	Amplitude Range (0-peak)
Thor/Agena, Booster S/N 353 and 356	Accelerometer	Endevco	2235C	1A38019	5-8000	± 40 g
	Amplifier	Endevco	2620	1A38030	20-10000	
DSV-2J, No. 20002, 20003 and 20006	Accelerometer/ Amplifier System	Electra-Scientific	ES-6717	1A79591-507	5-2000 flat to + 2% - 5%	± 30 g
Thor Asset, Booster S/N 232						
First Stage	Accelerometer	Endevco	2235C		5-8000	± 40 g
	Amplifier	Endevco	2620		20-10000	
Asset/Adapter Interstage	Accelerometer	Gulton	AXT-396 TU		10-300	± 25 g
	Amplifier	Gulton	FT-2605A (amplifier) FB-1807A (bias unit)		10-300	± 25 g
Thor/Delta/Asset, Booster S/N 240						
First Stage	Accelerometer/ Amplifier System	Electra-Scientific	ES-6725	1A79591-505	5-2000	± 30 g
Second Stage	Accelerometer/ Amplifier System	Electra Scientific	ES-6724	1A79591-503	5-2000	± 25 g
Asset/Adapter Interstage	Accelerometer	Gulton	AXT-396 TU		10-300	± 25 g
	Amplifier	Gulton	FT-2605A (amplifier) FB-1807A (bias unit)		10-300	± 25 g

* Note: All accelerometers are of piezoelectric type with the exception of the strain gage Statham accelerometer.

TABLE IX (CONTINUED)

TRANSDUCERS

Vehicle	Instrument*	Manufacturer	Manufacturer Model No.	Douglas Part No.	Frequency Response (cps)	Amplitude Range (0-peak)
Thor/Delta/Asset, Booster S/N 250						
Second Stage	Accelerometer/ Amplifier System	Electra-Scientific	ES-6724	1A79591-503	5-2000	± 25 g
Station 55	Accelerometer	Statham	S-14-0-521	7859658-21	0-25	± 20 g
	Amplifier	Statham	CA17-81	7859658-41	0-25	± 2 g
Asset/Adapter Interstage	Accelerometer	Gulton	AXT-396 TU		10-300	± 25 g
	Amplifier	Gulton	FT-2605A (amplifier FB-1807A (bias unit		10-300	± 25 g

* Note: All accelerometers are of piezoelectric type with the exception of the strain gage Statham accelerometer.

TABLE X

ACCELEROMETER LOCATION AND MOUNTING STRUCTURE CHARACTERISTICS

Vehicle	Accelerometer Locations	Accelerometer Orientation		Mounting Structure			
				Location	Resonant Frequency, cps		Amplification Factor
		Thrust	Radial		Thrust	Radial	
DSV-2J, No. 20002, 20003 and 20006	a. Guidance Section, Station 132	X	X	Flight Controller Support Bracket		27-30	2.2
						42	2.2
						46	2.1
						140	2.0
					140		1.7
Thor/Agena, Booster S/N 353 and 365	a. Engine Section, Station 651	X	X	Stringer/Rib Intersection at the base of the Power Distribution Box	150		1.4
					230		2.5
					380		2.3
					620		1.3
					1200		1.3
Thor/Asset, Booster S/N 232	a. Guidance Section, Station 141	X	X	BTL-600 Guidance Unit Support Bracket		72	5.0
						106	5.8
					32		2.3
					38		3.4
					880		2.5
	b. Asset/Adapter Interface	X		Cross Beam	Unknown		Unknown
Thor/Delta/Asset, Booster S/N 240	a. First Stage Guidance Section, Station 130	X	X	Flight Controller Support Bracket		27-30	2.2
						42	2.2
						46	2.1
						140	2.0
	b. Second Stage Guidance Section, Station -150	X	X	BTL-600 Guidance Unit Support Bracket	140		1.7
						100	1.75
						900	1.67
						960	4.3
					200		1.33
	c. Asset/Adapter Interface	X		Cross Beam	Unknown		Unknown

TABLE X (CONTINUED)

ACCELEROMETER LOCATION AND MOUNTING STRUCTURE CHARACTERISTICS (Continued)

Vehicle	Accelerometer Locations	Accelerometer Orientation		Mounting Structure			
				Location	Resonant Frequency, cps		Amplification Factor
		Thrust	Radial		Thrust	Radial	
Thor/Delta/Asset, Booster S/N 250	a. Second Stage Engine Section, Station 55	X		Bracket	Unknown		Unknown
	b. Second Stage Guidance Section, Station -150	X	X	BTL-600 Guidance Unit Support Bracket		100 900 960	1.75 1.67 4.3
					200		1.33
	c. Asset/Adapter Interface	X		Cross Beam	Unknown		Unknown

TABLE XI

TELEMETRY CHANNELS

Missile	Axis of Excitation	Subcarrier Center Frequency (kc)	Percent Deviation	Nominal Intelligible Upper Frequency Limit (cps)
DSV-2J, No. 20002	Thrust Radial	22 40	± 15% ± 15%	660 1200
DSV-2J, No. 20003	Thrust Radial	22 40	± 15% ± 15%	660 1200
DSV-2J, No. 20006	Thrust Radial	22 40	± 15% ± 15%	660 1200
Thor Agena, Booster S/N 353	Thrust Pitch	40 22	± 15% ± 15%	1200 660
Thor Agena, Booster S/N 365	Thrust Pitch	40 22	± 15% ± 15%	1200 660
Thor/Asset, Booster S/N 232				
a. Station 141	Thrust, Radial (Commutated at 3 second intervals)	22	± 15%	660
b. Asset/Adapter Interface	Thrust	14.5	± 7.5%	220
Thor/Delta/Asset, Booster S/N 240				
a. Station 130	Thrust, Radial (Commutated at 2.5 second intervals)	22	± 15%	660
b. Station -150	Thrust Radial (Commutated at 2.5 second intervals)	40	± 15%	1200

TABLE XI (CONTINUED)

TELEMETRY CHANNELS (Continued)

Missile	Axis of Excitation	Subcarrier Center Frequency (kc)	Percent Deviation	Nominal Intelligible Upper Frequency Limit (cps)
Thor/Delta/Asset, Booster S/N 240 (Continued)				
c. Asset/Adapter Interface	Thrust	10.5	± 7.5%	160
Thor/Delta/Asset, Booster S/N 250				
a. Station 55	Thrust	1.7	± 7.5%	25
b. Station -150	Thrust, Radial (Commutated at 3 second intervals)	4.0	± 15%	1200
c. Asset/Adapter Interface	Thrust	14.5	± 7.5%	200

TABLE XII

DATA ACQUISITION AND DATA REDUCTION EQUIPMENT

	MANUFACTURER	DOUGLAS PART NO.	MANUFACTURERS MODEL NO.
A. DATA ACQUISITION EQUIPMENT			
Low Pass Filter	Douglas	1A21785	
Voltage Controlled Subcarrier Oscillator (VCO)	Bendix	7833105	
Wide Band Amplifier	Bendix	7833107	
Transmitter	Electromechanical Research	1A19954	
Tape Recorders (Ground Station)	Ampex Ampex		FR-107 FR-104
B. DATA REDUCTION EQUIPMENT			
Tape Recorder	Ampex		FR-600
Discriminator	Electromechanical Research		67 or 189
Low Pass Filter	Electromechanical Research		GF-67DL or GF-67DLL
Graphic Level Recorder	Sanborn		154-100B
Log-Audio Pre-Amplifier	Sanborn		150-1400
Oscillograph	Honeywell		Viscorder Model 1012
Printer	Stromberg Carlson		4020
Digital Computer	IBM		7094
Analog-to-Digital Converter	Packard Bell		M2

TABLE XIII

SINUSOIDAL VIBRATIONS

Vehicle	Location	Time After Main Engine Ignition (sec)	Frequency (cps)	Vibration Level (g, 0-pk) Thrust Axis	Pitch Axis
Thor/Agena, Booster S/N 353	Station 651	0-1	15	1.2	
		48-49	1000	8	4
		62-66	1000	14	7
		110	1000	21	10
		138-146	20	4	
			1000	10	8
			1250	28	15
Thor/Agena, Booster S/N 365	Station 651	0-1	15	1	
		110	1000	14	7
		140-145	20	5	
			1000	18	4.8
DSV-2J No. 20006 (Booster S/N 209)	Station 132	0-1	17	2.5	
		115-144	28	2.1	
Thor/Asset, Booster S/N 232	Station 141	0-1	17	1	
Thor/Delta/Asset, Booster S/N 240	Station 130	0-1	16	0.75	
		148-158	28	0.25	
Thor/Delta/Asset, Booster S/N 250	a. Station -150	0-1	16	1.0	
		158	27	0.3	
	b. Station 55	159	27	0.3	
	c. Asset/Adapter Interface	0-1	16	0.6	
		150-158	27	0.7	

ACCELEROMETER LOCATIONS, THOR AGENAS, BOOSTER S/N 353 AND 365

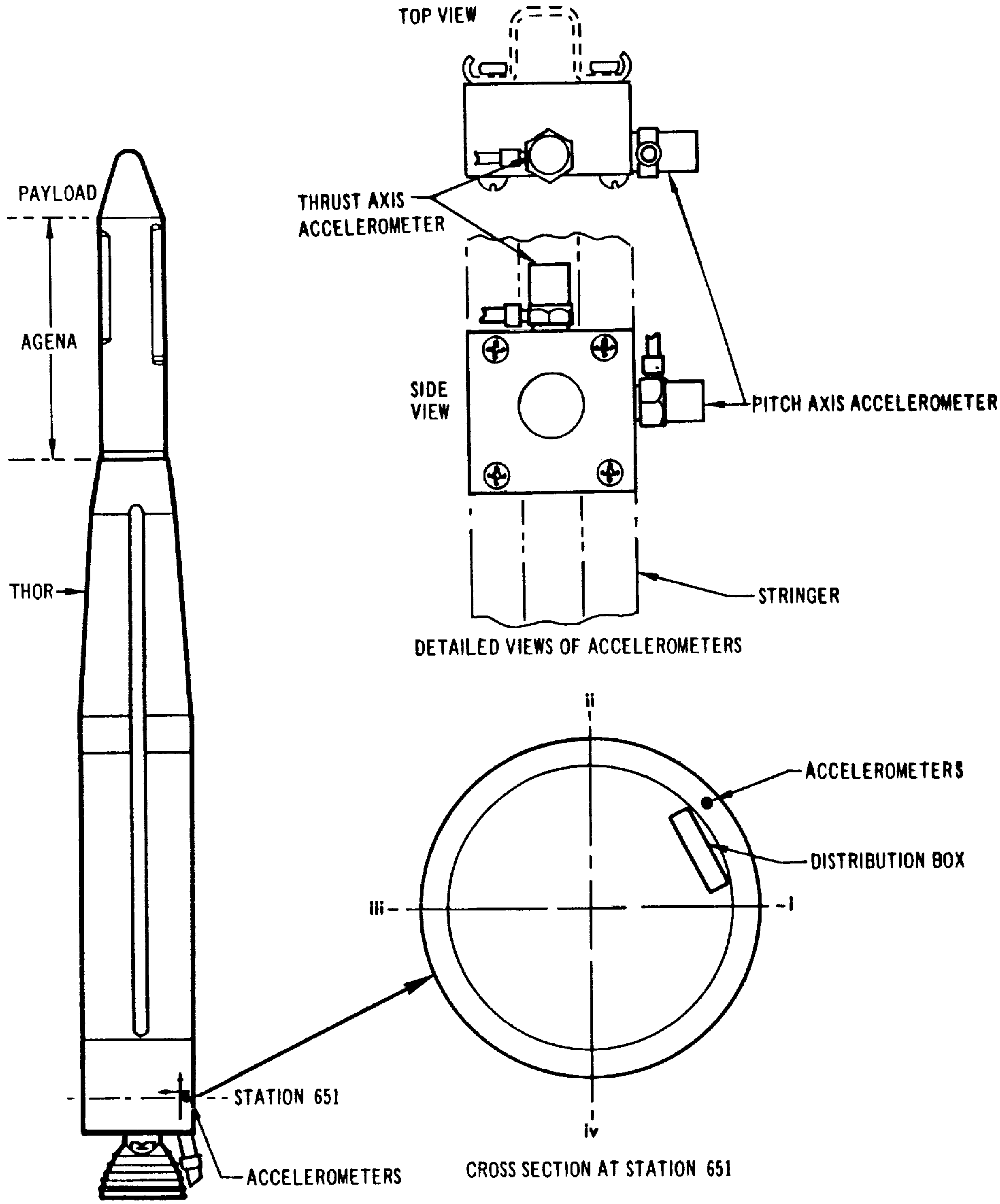


FIGURE 1

ACCELEROMETER LOCATIONS, THOR/ASSET DSV-2F

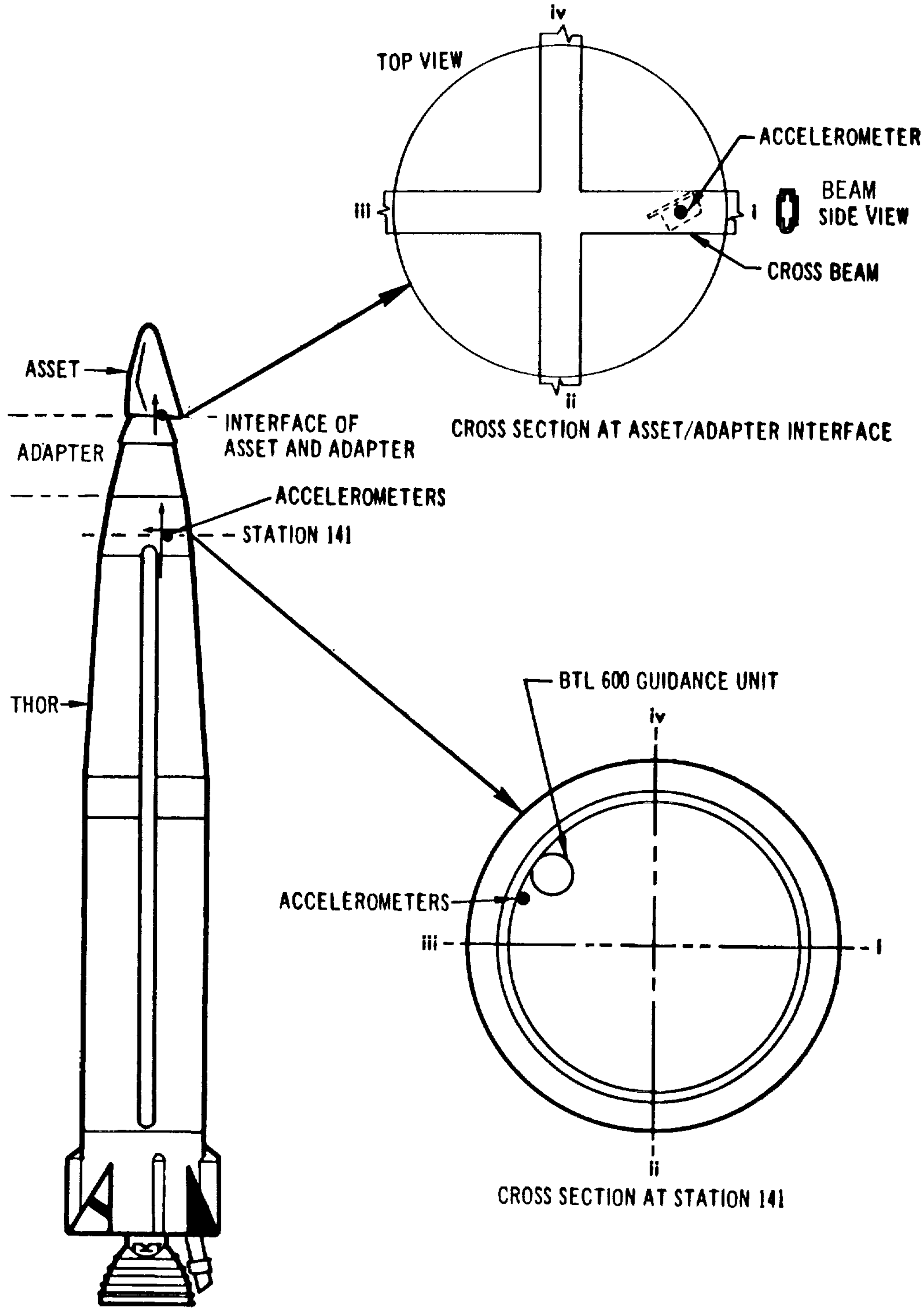
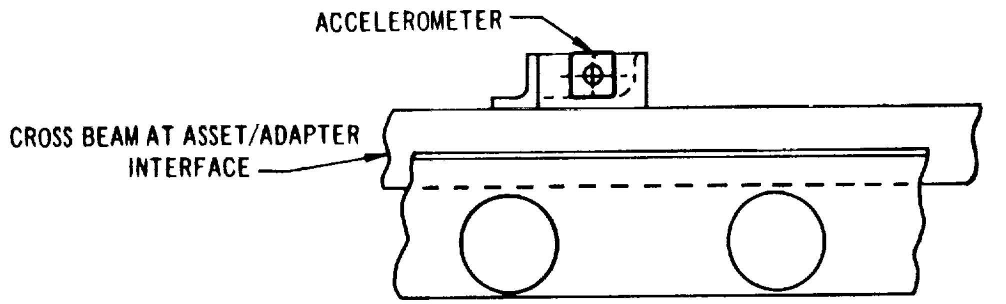
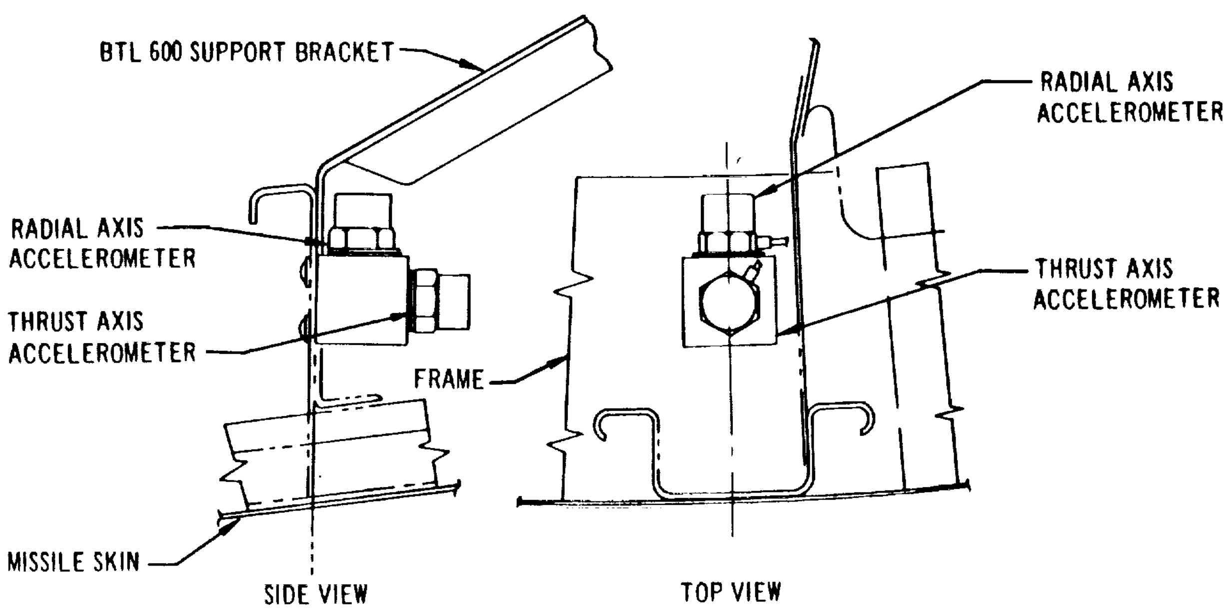


FIGURE 2



DETAILED VIEW OF ACCELEROMETER AT ASSET/ADAPTER INTERFACE



DETAILED VIEWS OF ACCELEROMETERS AT STATION 141

FIGURE 2 (CONTINUED)

ACCELEROMETER LOCATIONS, THOR/DELTA/ASSET DSV-2G, BOOSTER S/N 240

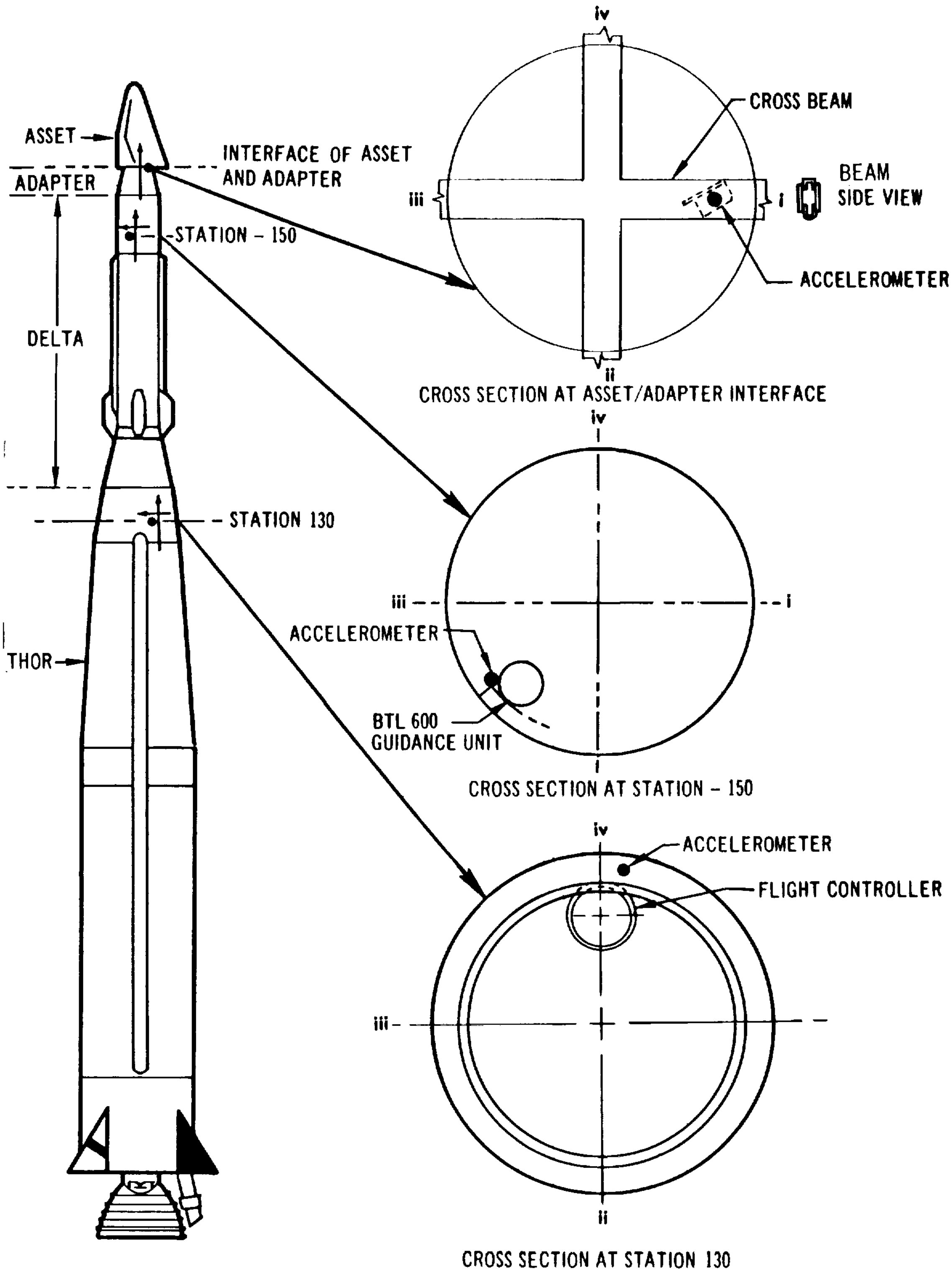
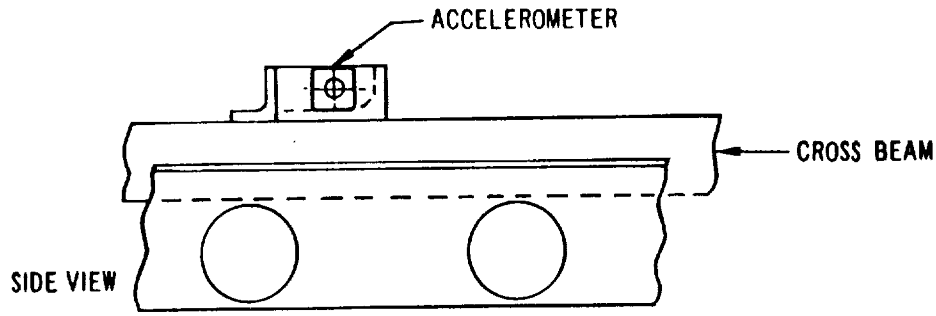
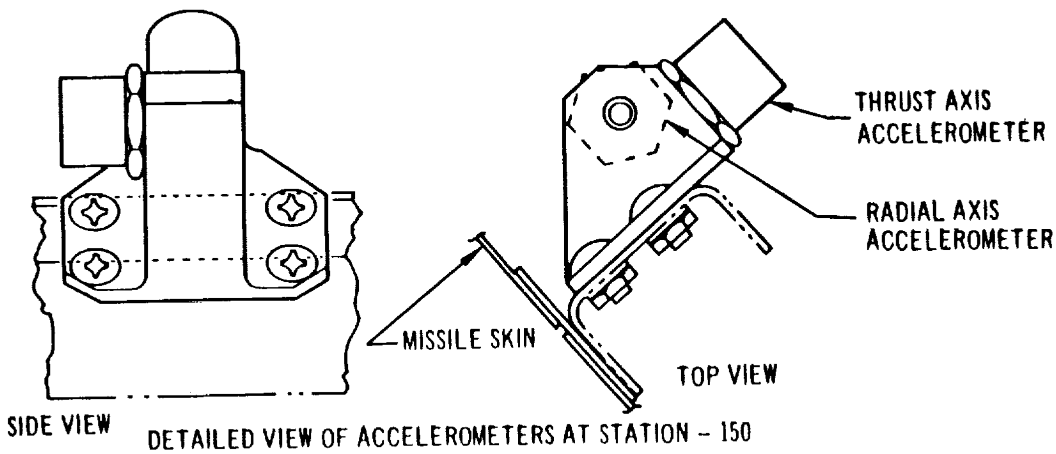


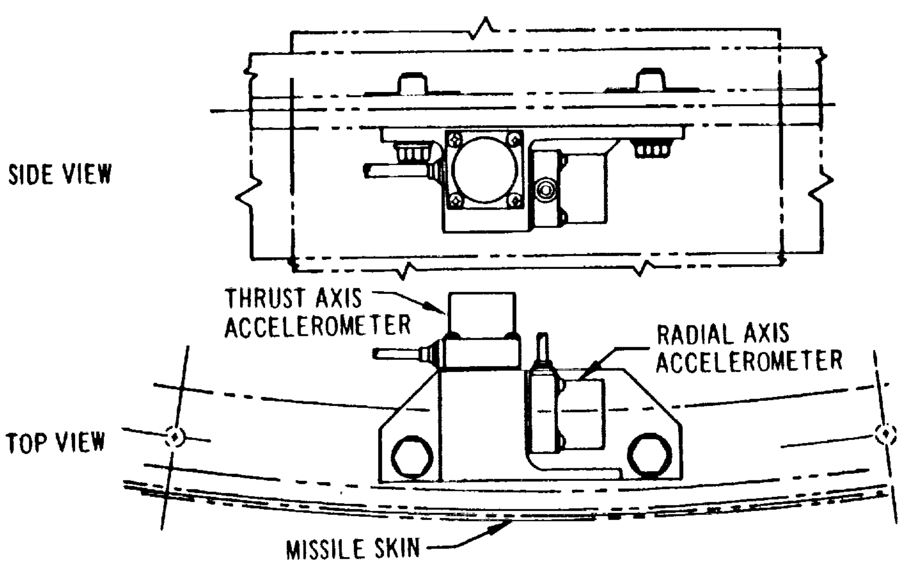
FIGURE 3



DETAILED VIEW AT ASSET/ADAPTER INTERFACE



DETAILED VIEW OF ACCELEROMETERS AT STATION - 150



DETAILED VIEW OF ACCELEROMETERS AT STATION 130

FIGURE 3 (CONTINUED)

ACCELEROMETER LOCATIONS, THOR/DELTA/ASSET DSV-2G, BOOSTER S/N 250

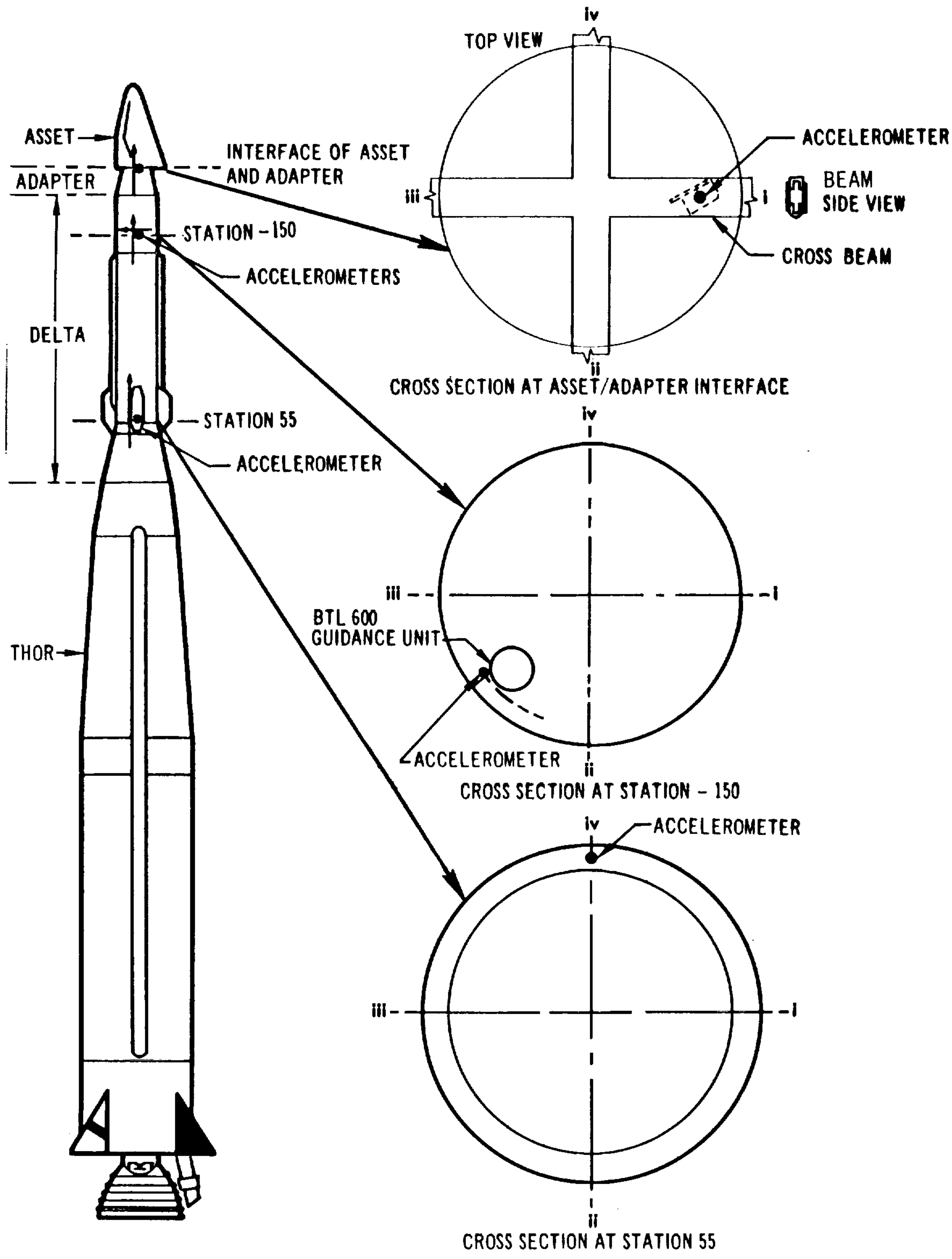
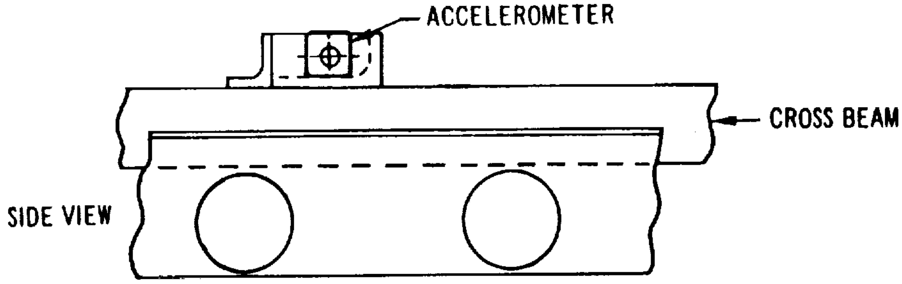
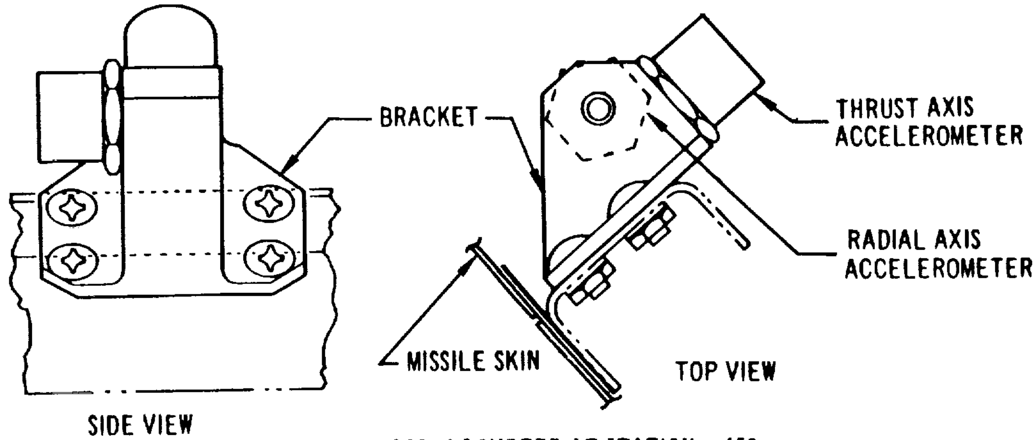


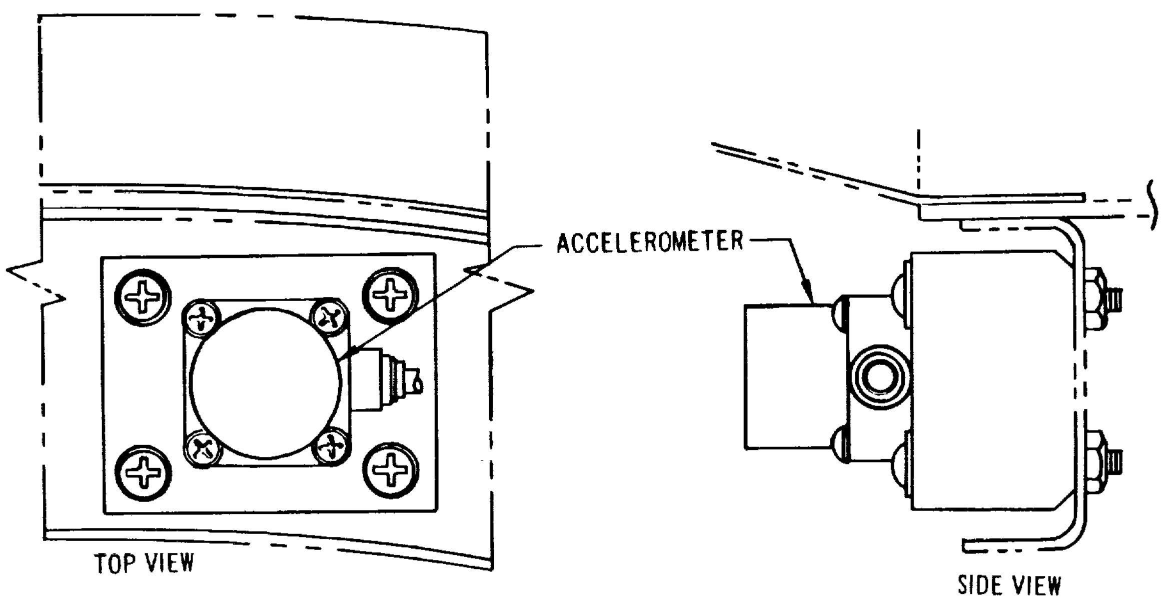
FIGURE 4



DETAILED VIEW OF ACCELEROMETER AT ASSET/ADAPTER INTERFACE



DETAILED VIEW OF ACCELEROMETER AT STATION - 150



DETAILED VIEWS OF ACCELEROMETER AT STATION 55

FIGURE 4 (CONTINUED)

ACCELEROMETER LOCATIONS, DSV-2J

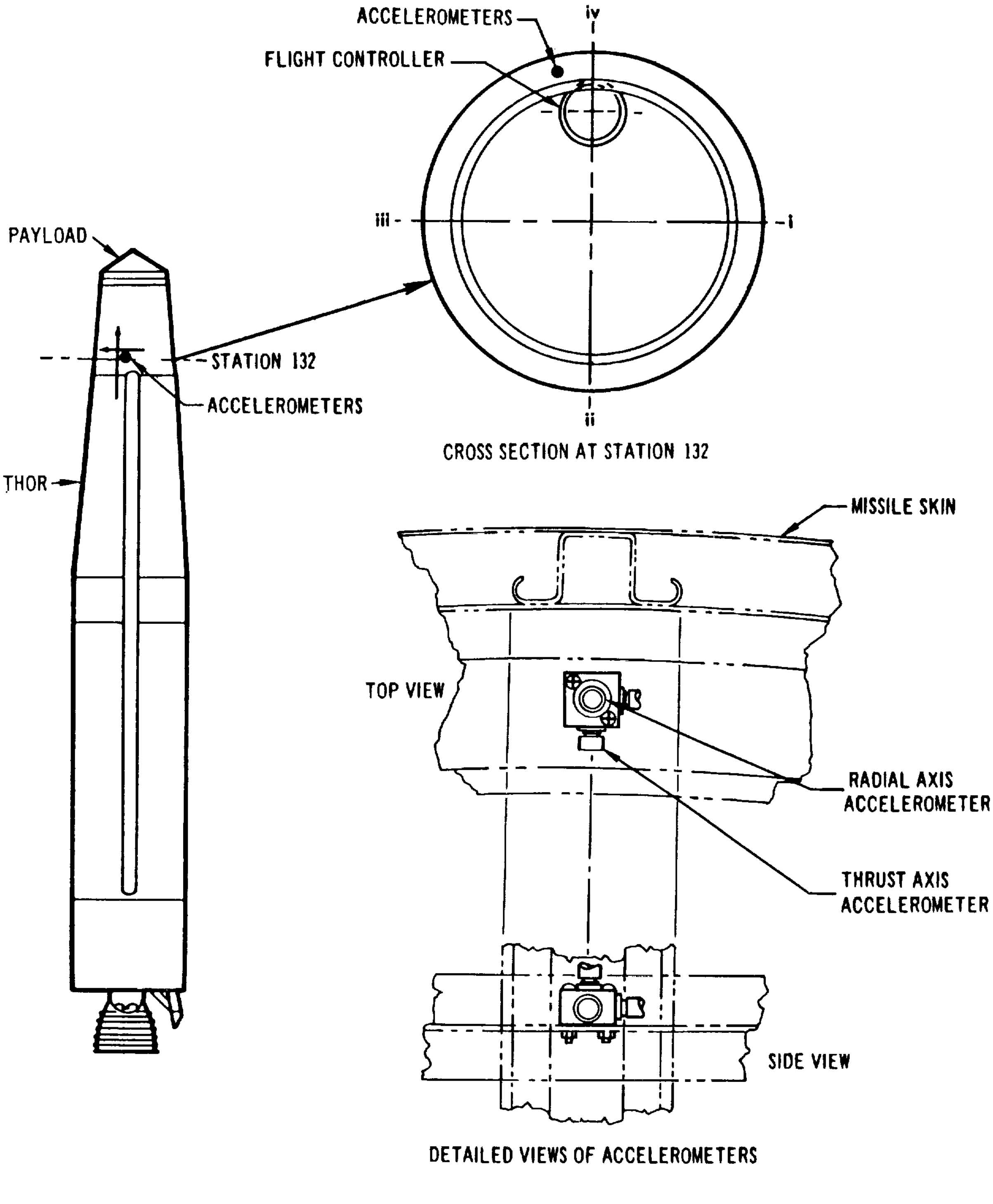


FIGURE 5

DATA ACQUISITION SYSTEM

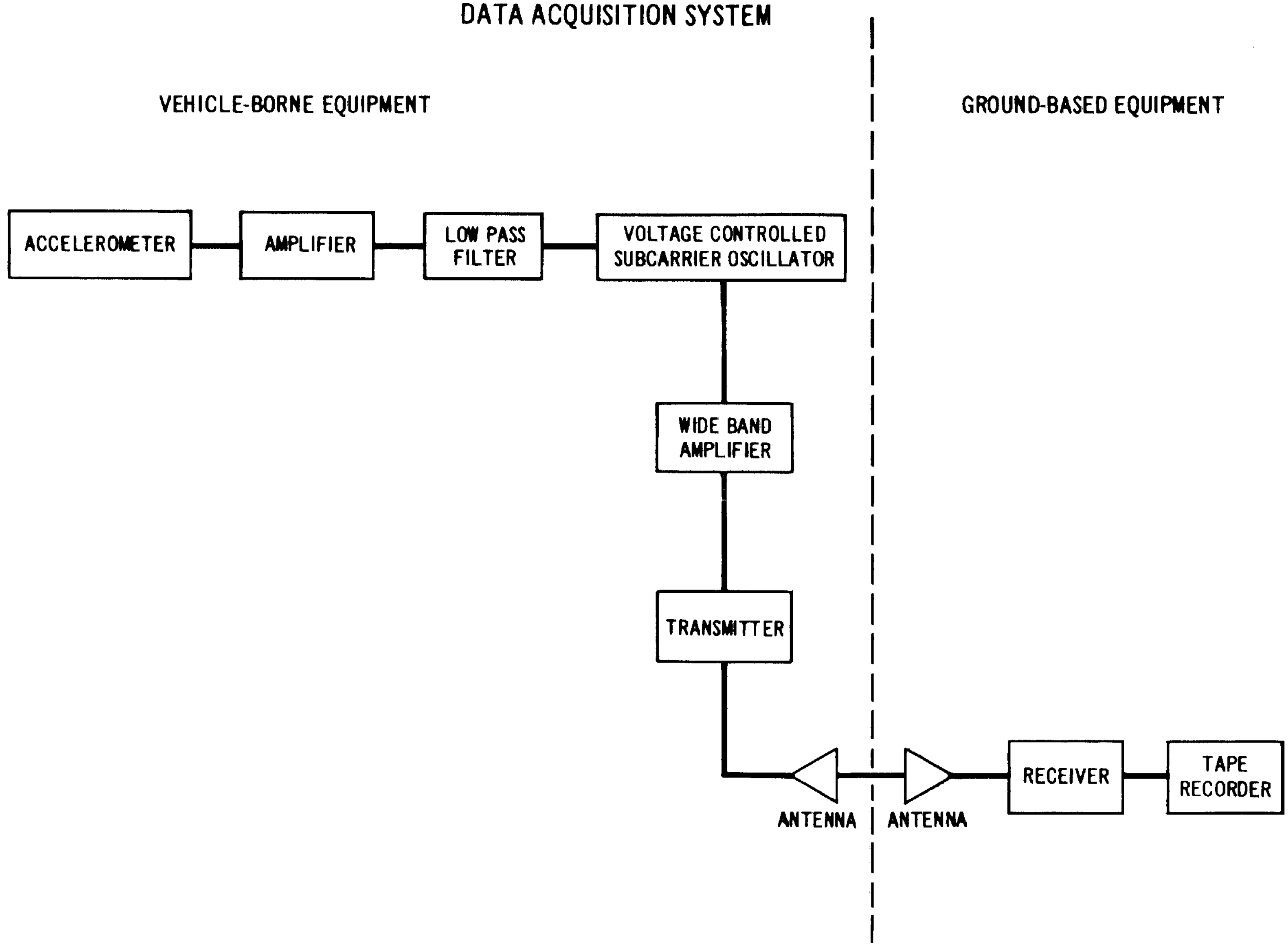


FIGURE 6

DATA REDUCTION SYSTEM

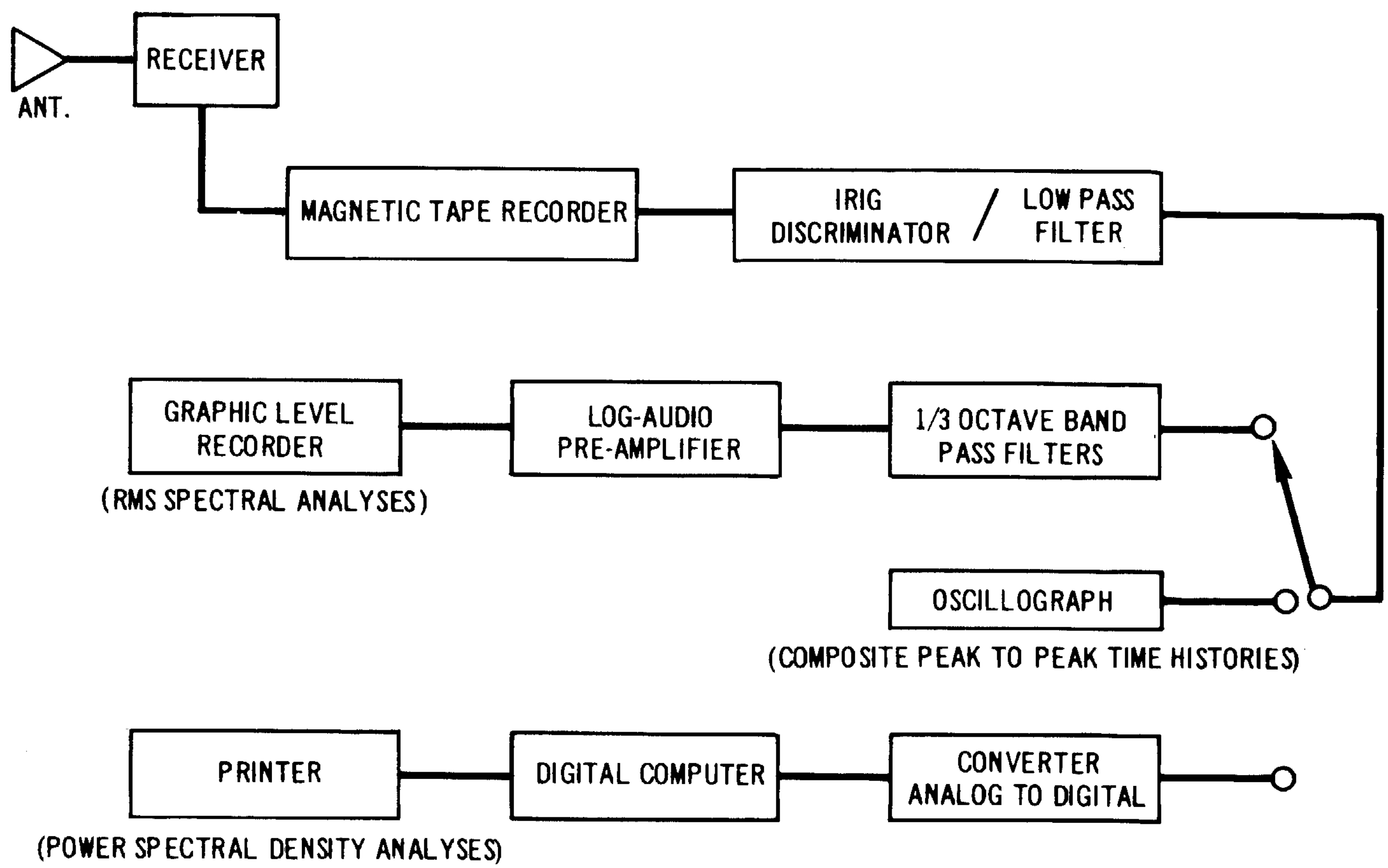


FIGURE 7

TIME HISTORY OF VIBRATION LEVELS IN THE THOR BOOSTER ENGINE COMPARTMENT, THOR AGENA, BOOSTER S/N 353

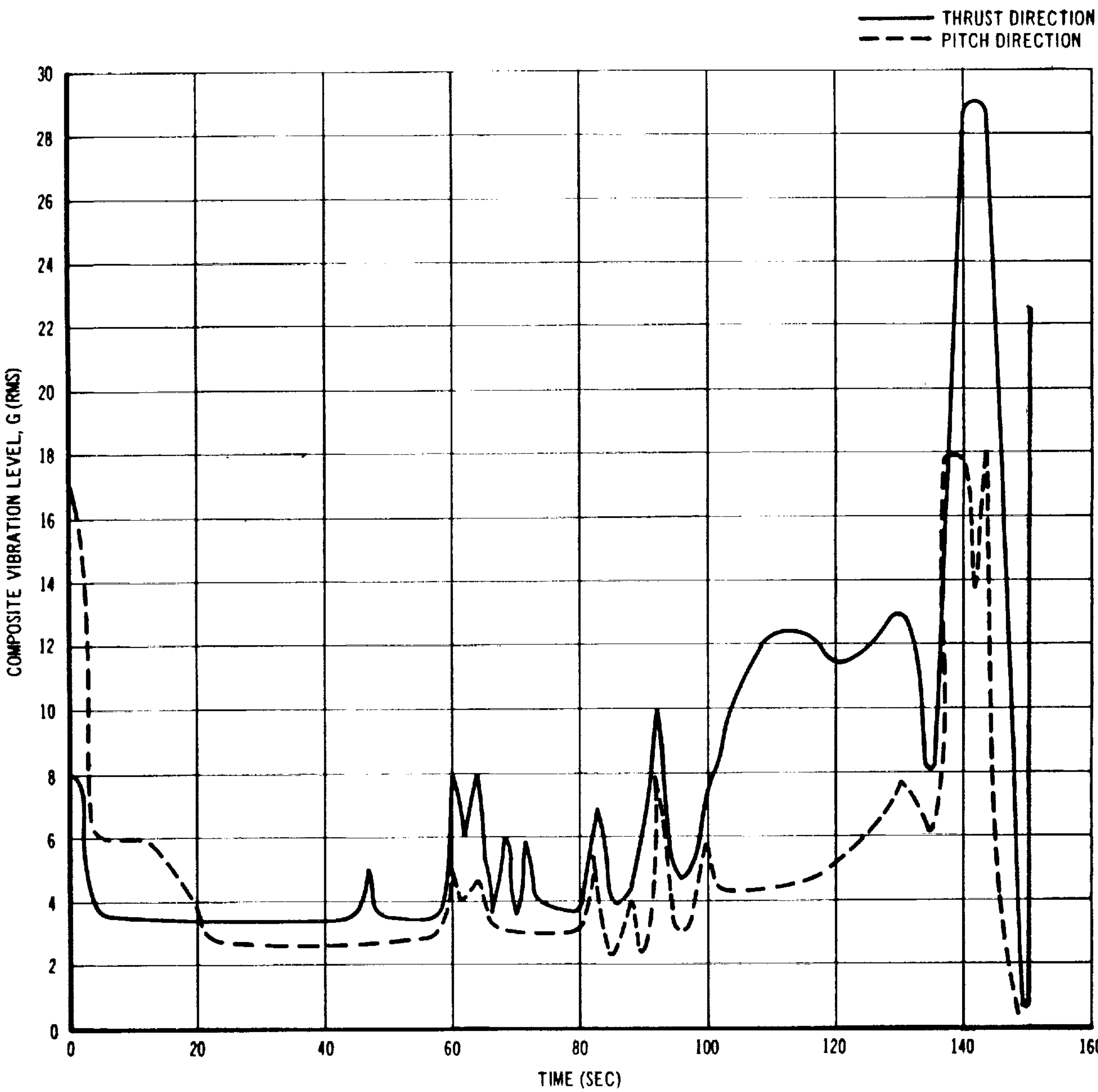


FIGURE 8

TIME HISTORY OF VIBRATION LEVELS IN THE THOR BOOSTER ENGINE COMPARTMENT
THOR AGENA, BOOSTER S/N 365

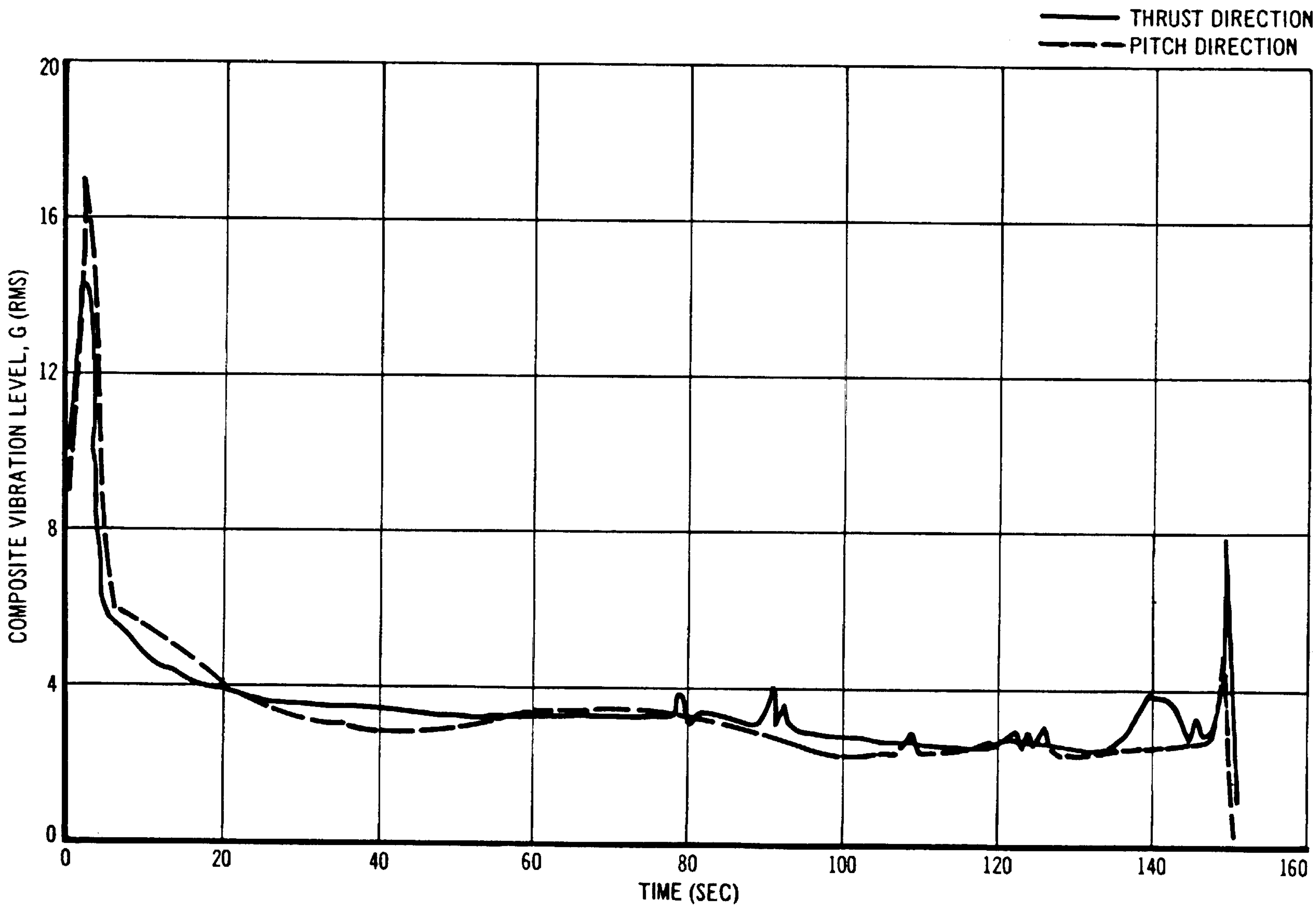


FIGURE 9

TIME HISTORY OF VIBRATION LEVELS IN THE GUIDANCE SECTION, DSV-2J NO. 20002
RADIAL DIRECTION

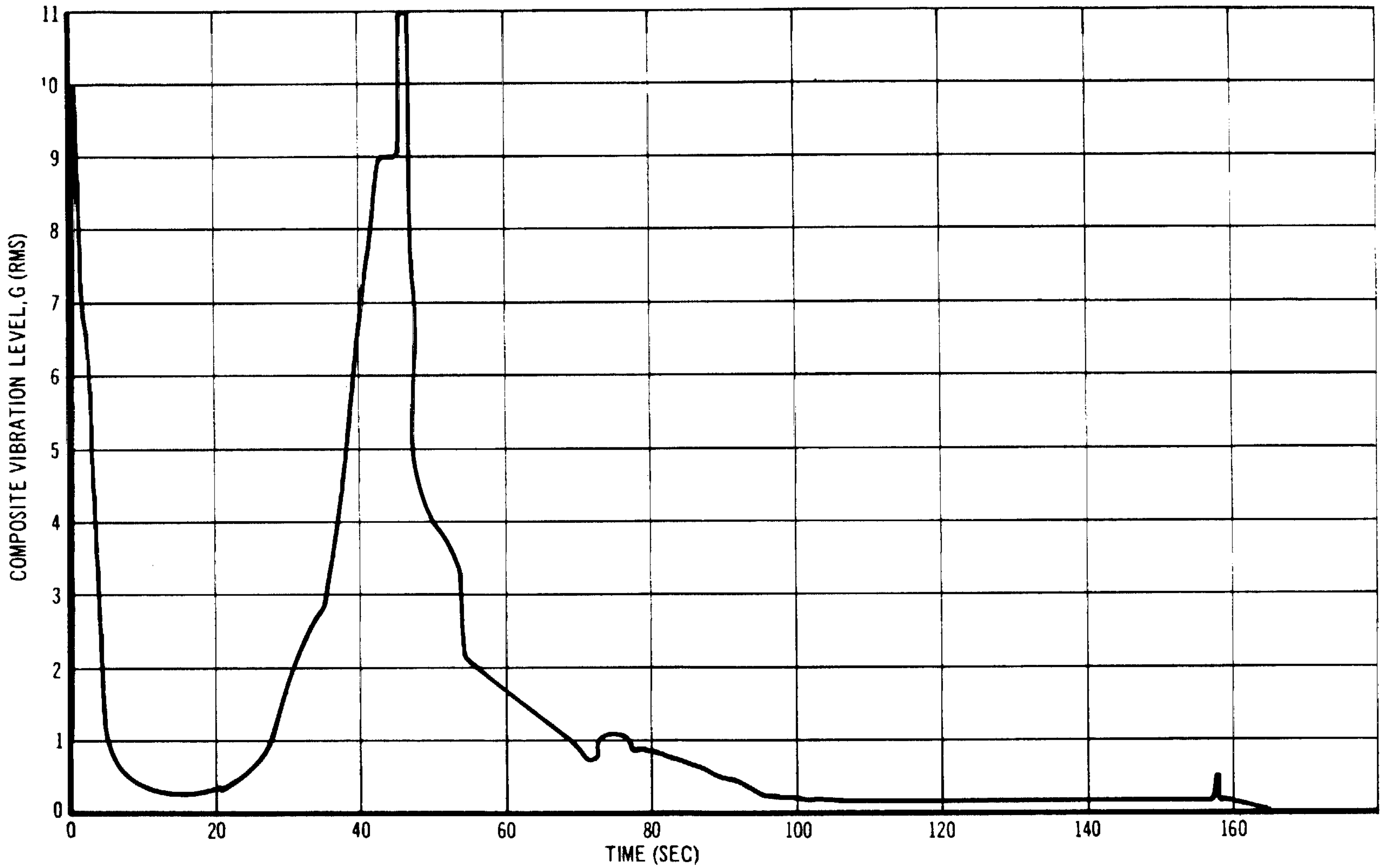


FIGURE 10

TIME HISTORY OF VIBRATION LEVELS IN THE GUIDANCE SECTION, DSV-2J NO. 20003
RADIAL DIRECTION

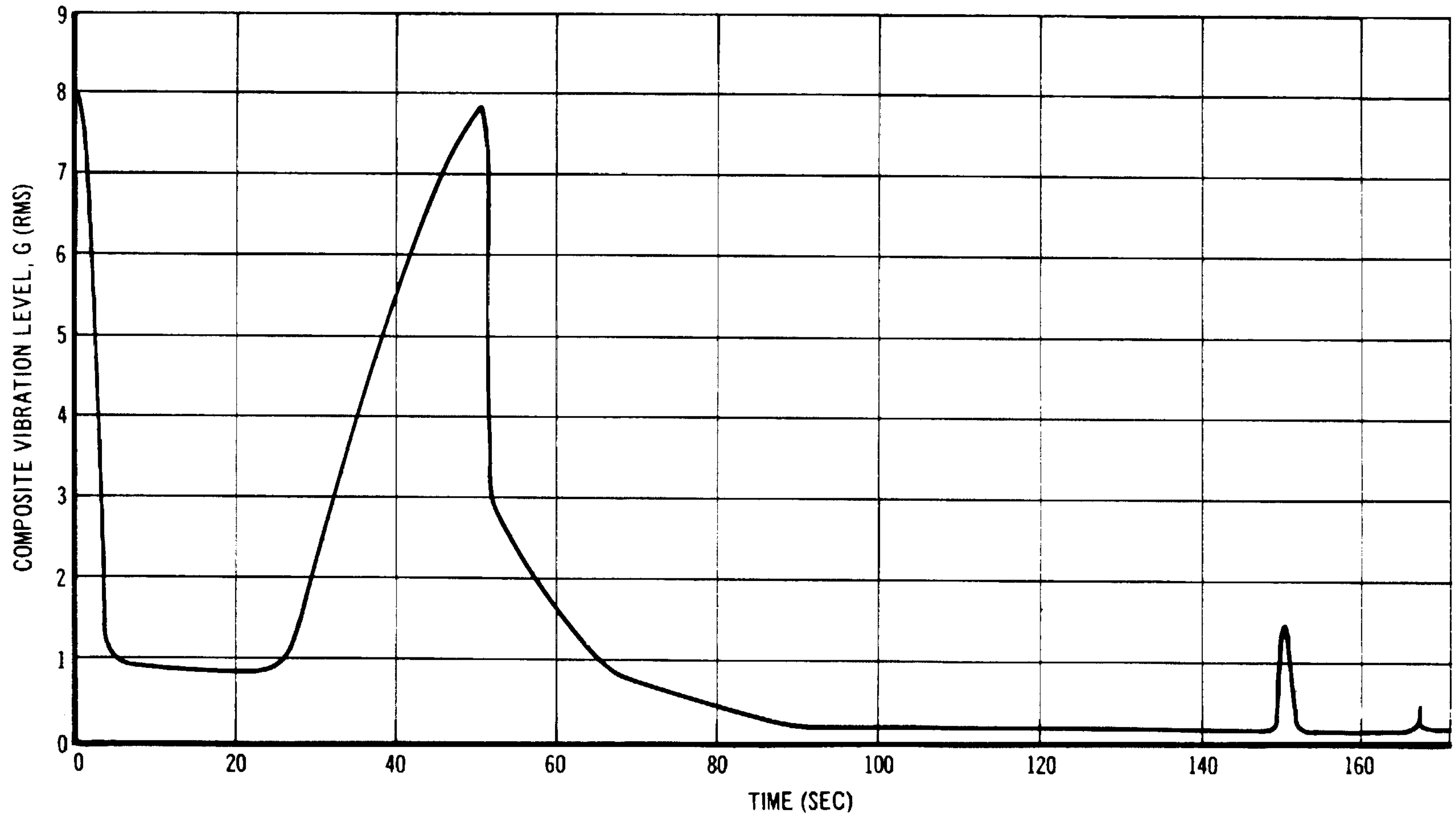


FIGURE 11

TIME HISTORY OF VIBRATION LEVELS IN THE GUIDANCE SECTION, DSV-2J NO. 20006

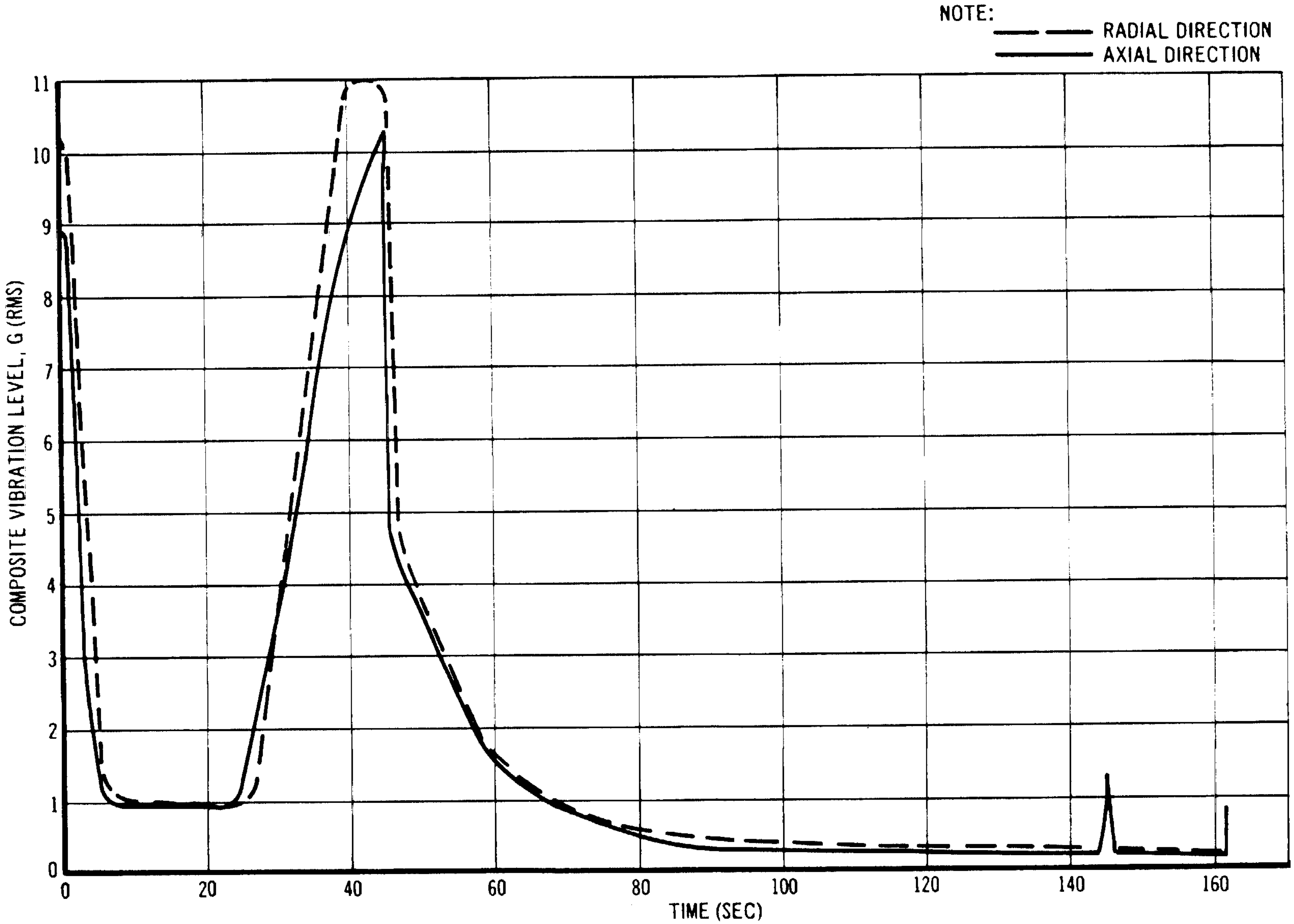


FIGURE 12

TIME HISTORY OF COMPOSITE VIBRATION LEVELS
AT THE BTL 600 GUIDANCE UNIT
THOR/ASSET DSV-2F, BOOSTER NO. 232

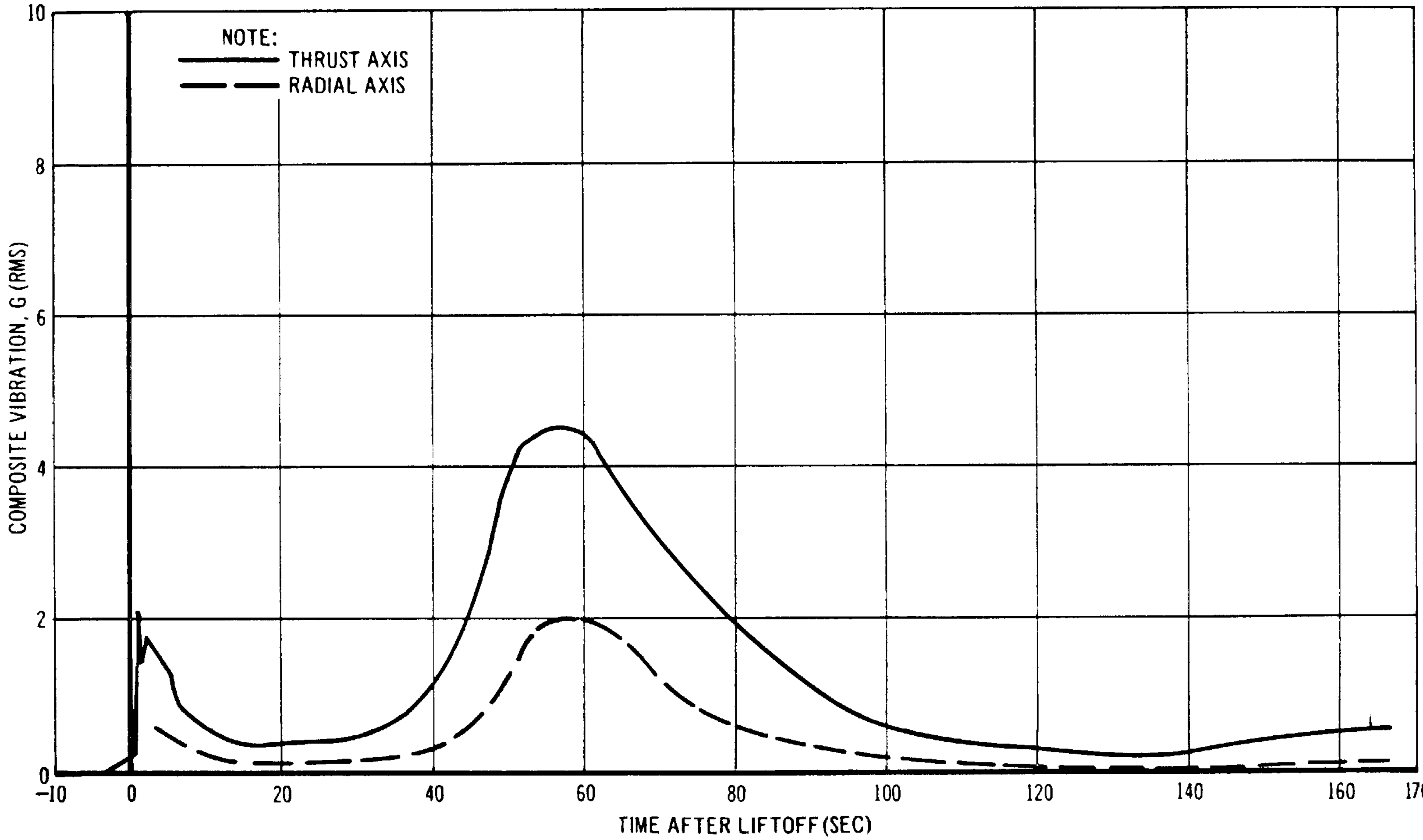


FIGURE 13

TIME HISTORY OF COMPOSITE VIBRATION LEVELS
AT ASSET PAYLOAD/ADAPTER INTERFACE
THOR/ASSET DSV-2F, BOOSTER S/N 232
THRUST AXIS

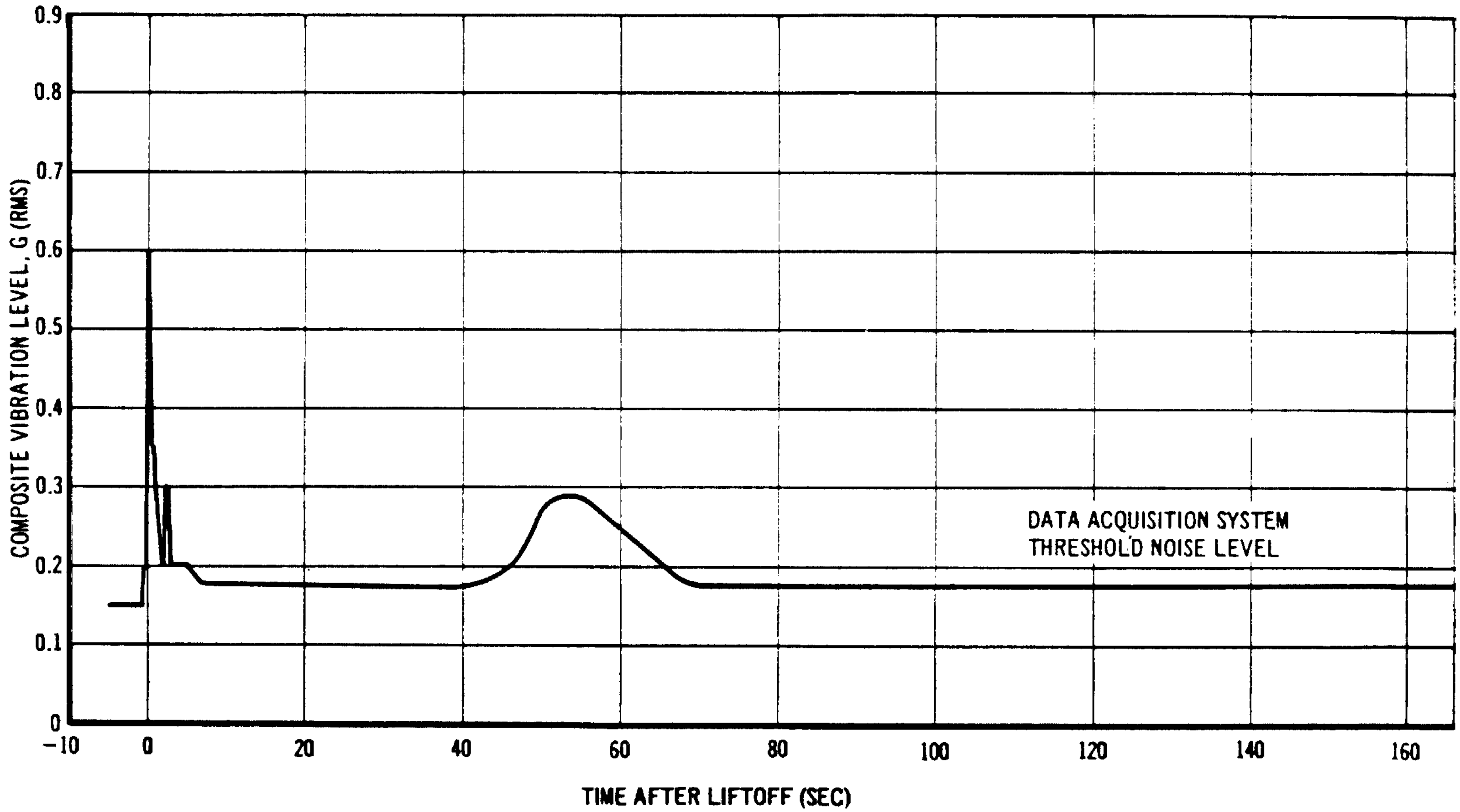


FIGURE 14

TIME HISTORY OF VIBRATION AT THE FLIGHT CONTROLLER
FIRST STAGE GUIDANCE SECTION
THOR/DELTA/ASSET DSV-2G BOOSTER S/N 240

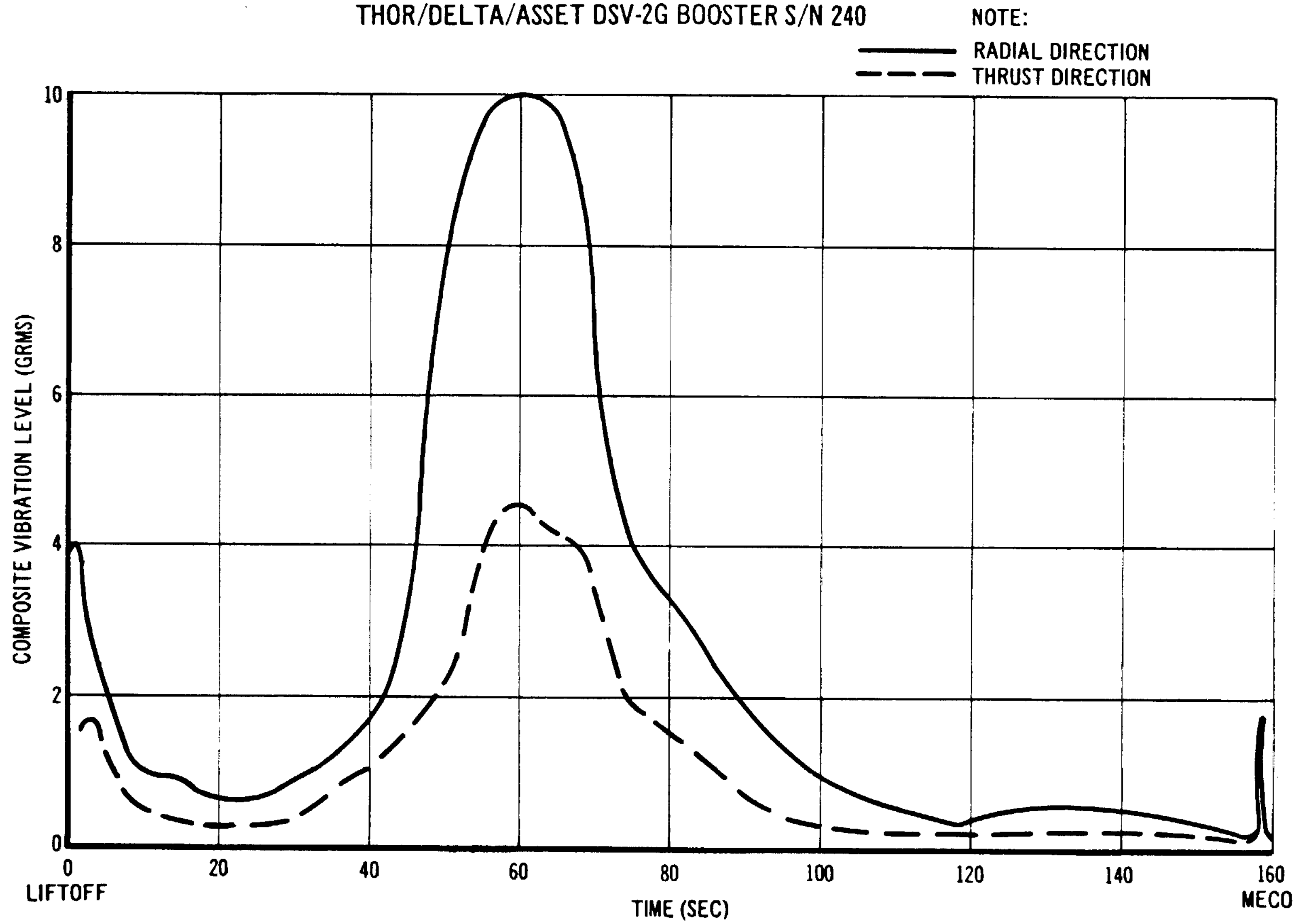


FIGURE 15

TIME HISTORY OF VIBRATION AT THE BTL GUIDANCE UNIT
SECOND STAGE GUIDANCE SECTION
THOR/DELTA/ASSET DSV-2G, BOOSTER S/N 240

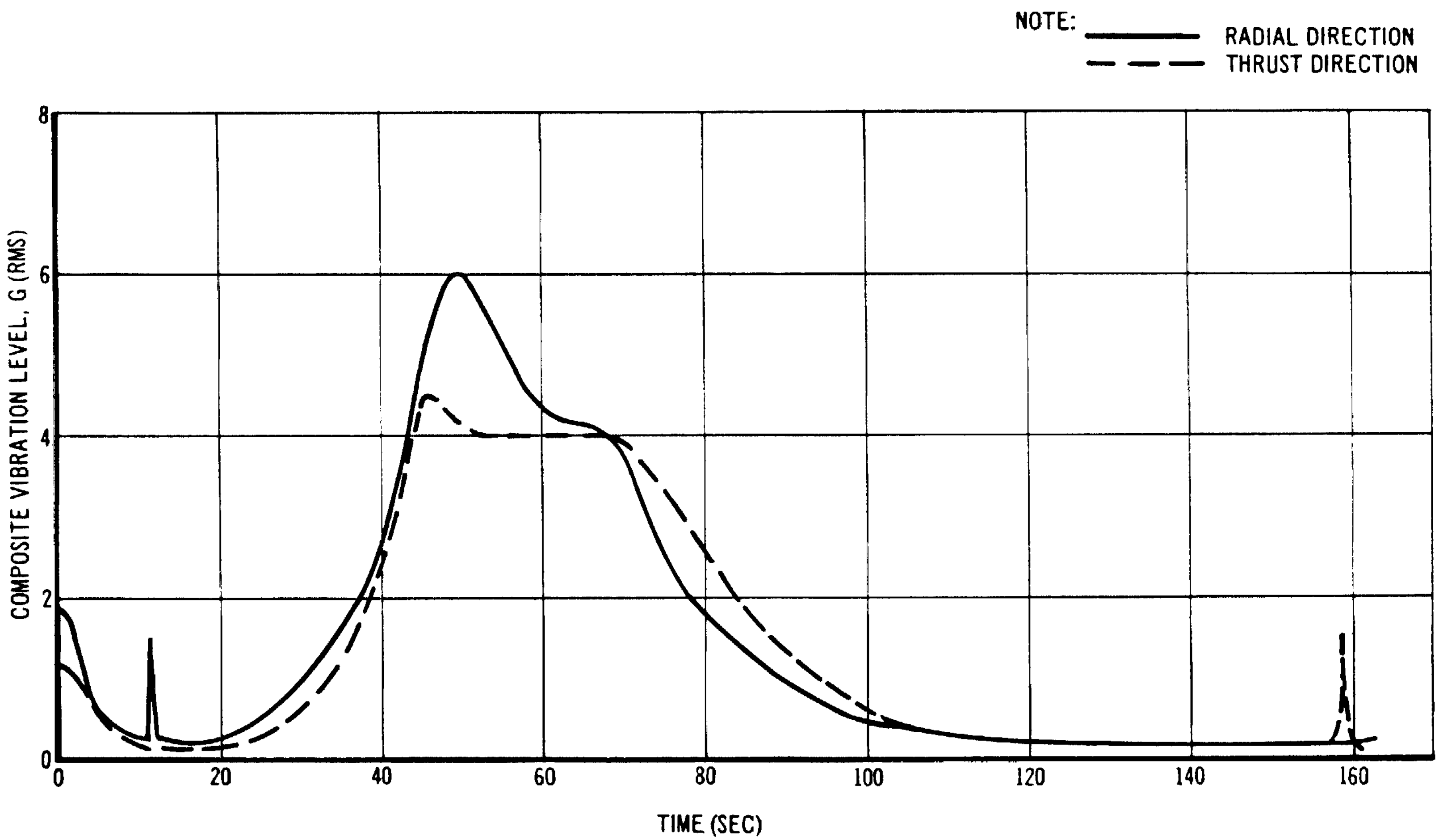


FIGURE 16

TIME HISTORY OF VIBRATION LEVELS
IN THE SECOND STAGE (BTL-600 GUIDANCE UNIT)
THOR/DELTA/ASSET DSV-2G, BOOSTER S/N 250

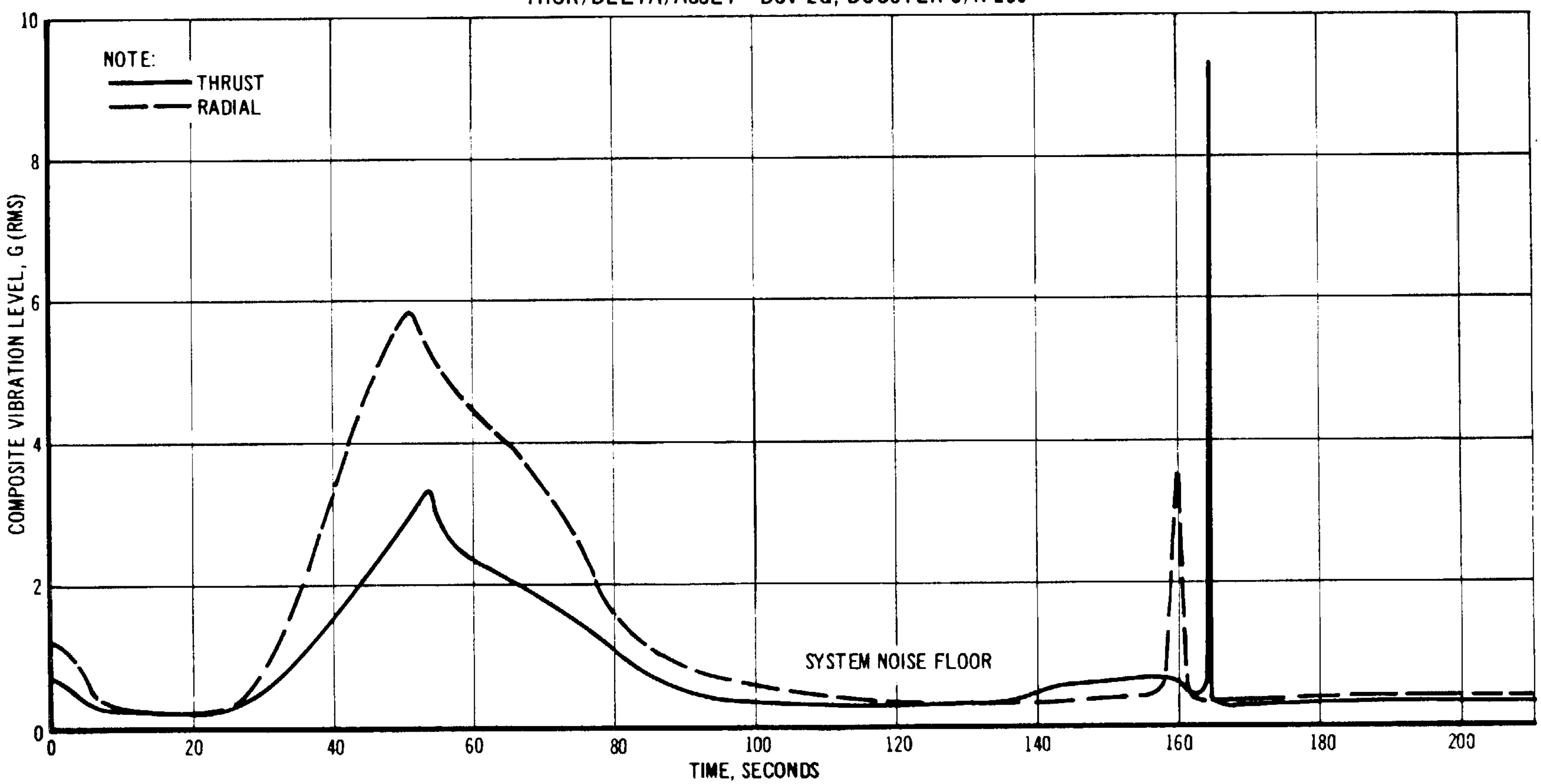


FIGURE 17

TIME HISTORY OF VIBRATION LEVELS
AT THE ASSET/ADAPTER INTERFACE
THOR/DELTA/ASSET DSV-2G, BOOSTER S/N 250

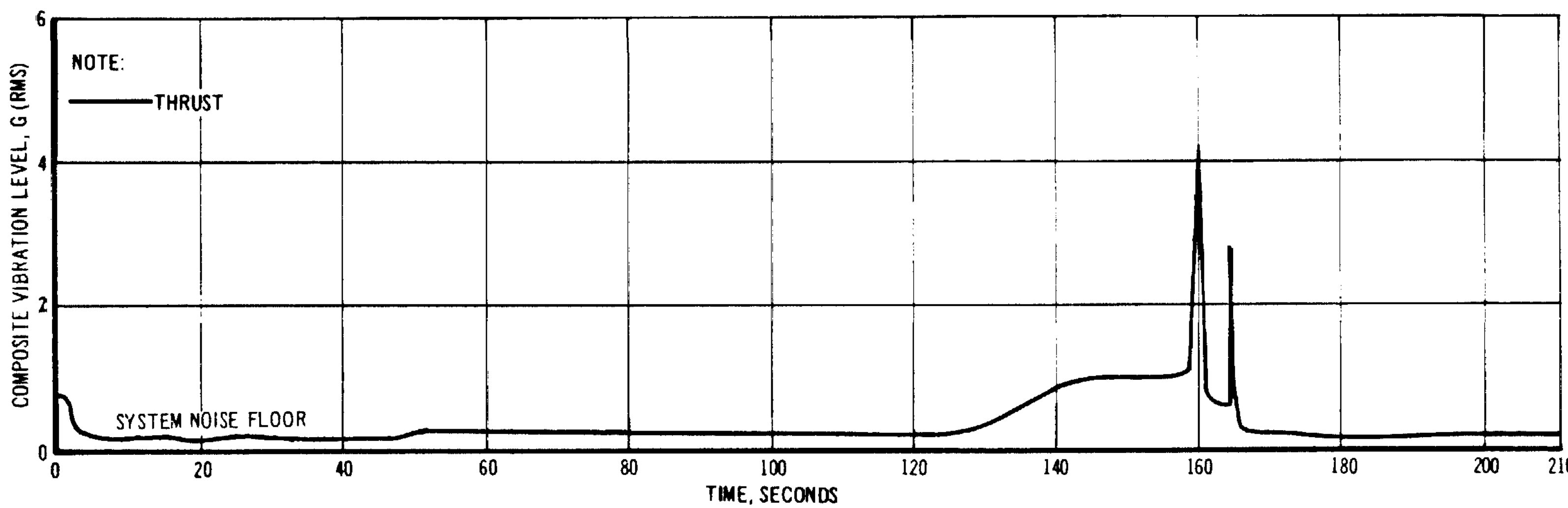


FIGURE 18

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/AGENA, BOOSTER S/N 353

BOOSTER ENGINE COMPARTMENT (STATION 651)

LIFTOFF PERIOD

THRUST AXIS

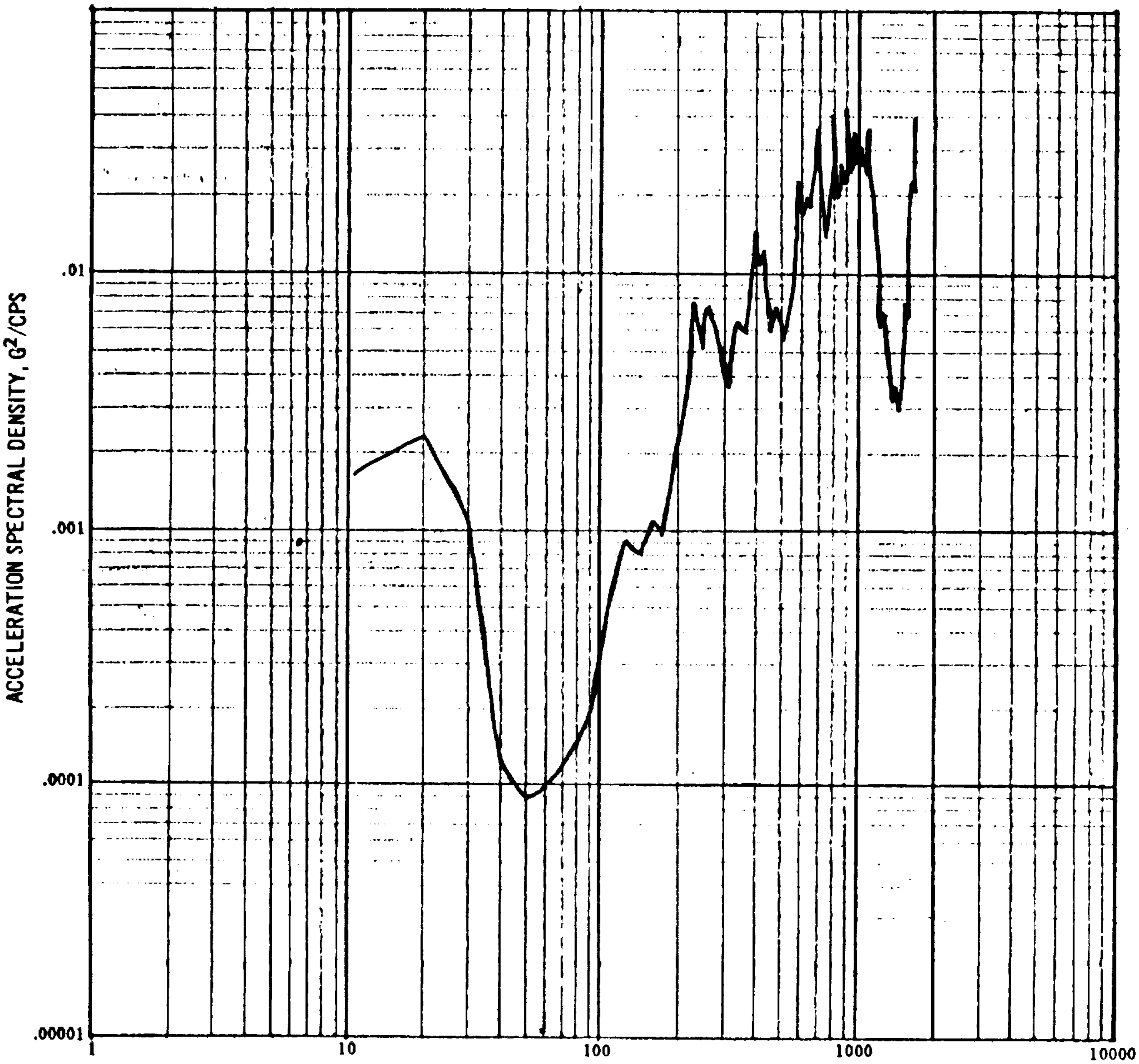


FIGURE 19a

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
LIFTOFF PERIOD
PITCH AXIS

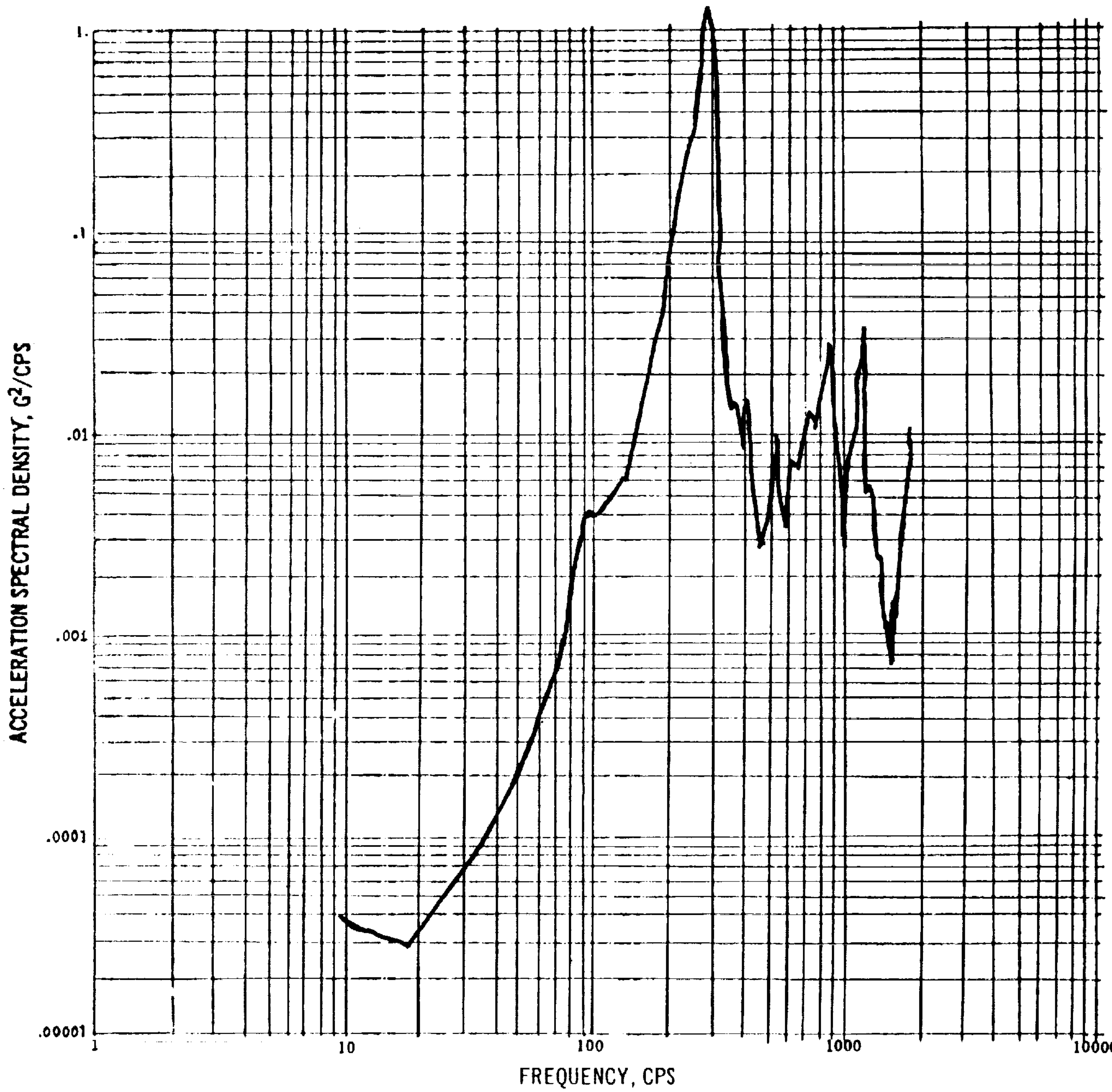


FIGURE 19 b

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
STEADY STATE BURNING PERIOD (T + 20 SECONDS)
THRUST AXIS

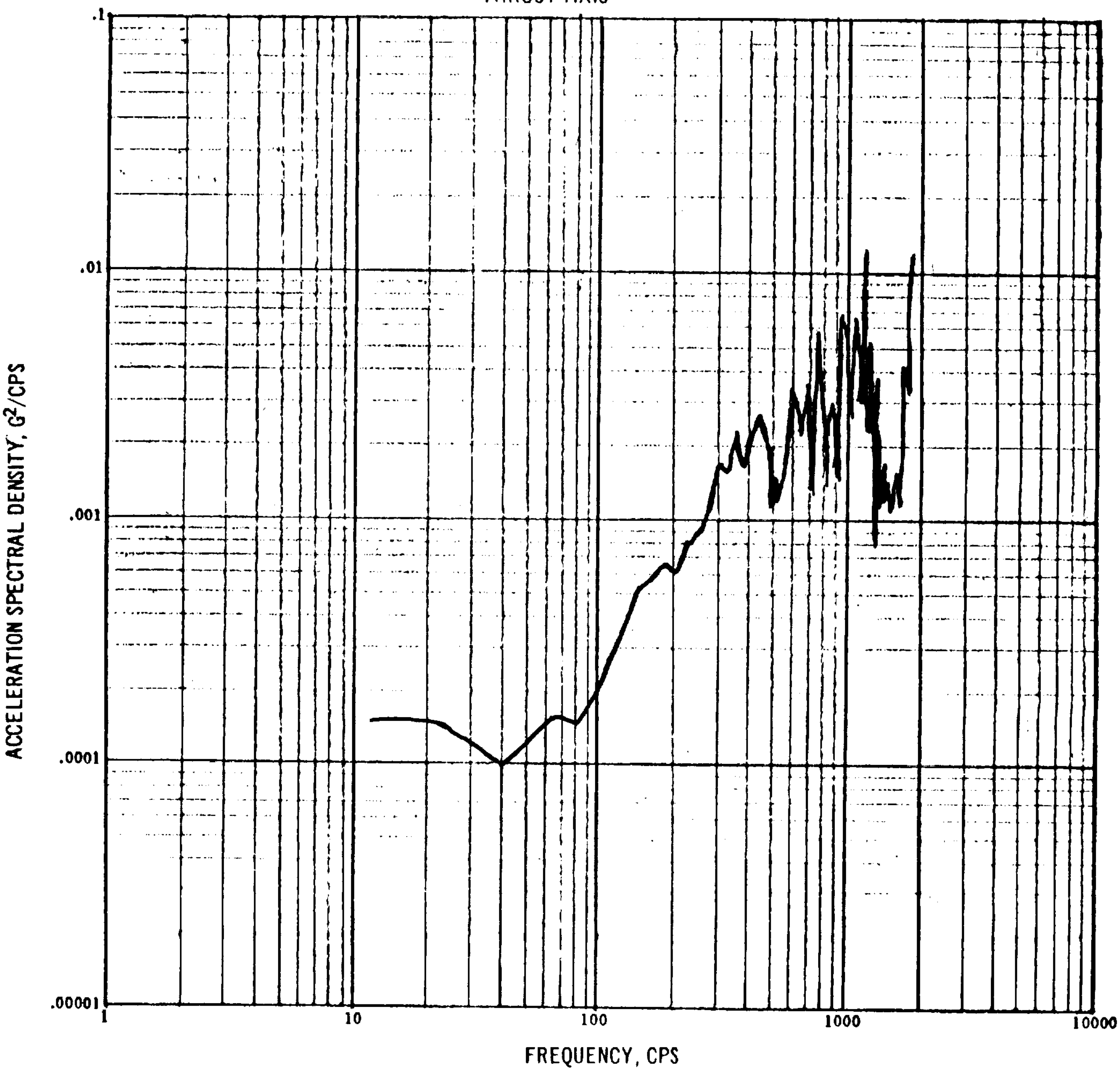
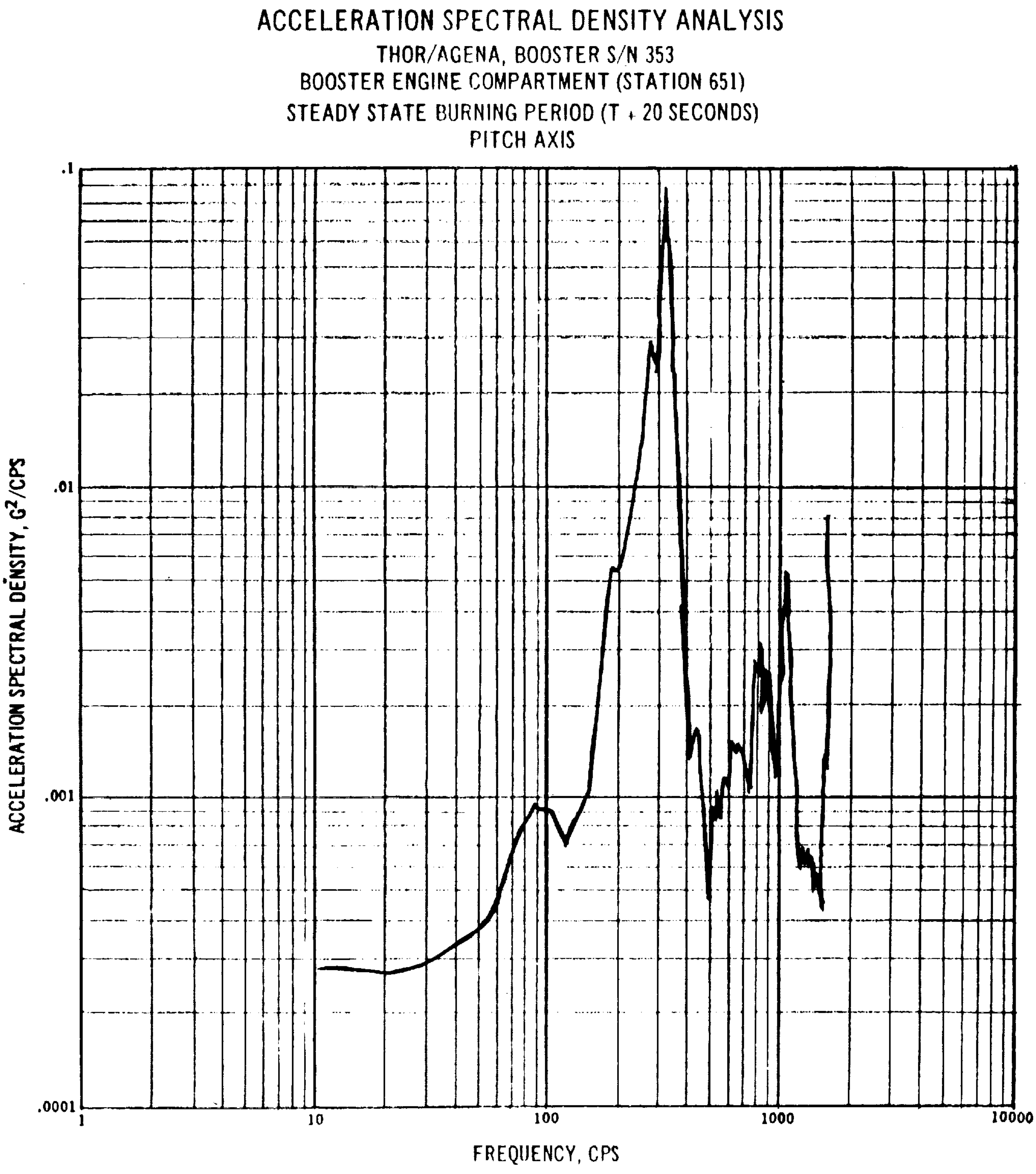


FIGURE 19 C



ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
STEADY STATE BURNING PERIOD (T + 20 SECONDS)
PITCH AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
.1
.01
.001
.0001
1
10
100
1000
10000
FREQUENCY, CPS

FIGURE 19 d

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
MACH 1 (T + 48 SECONDS)
THRUST AXIS

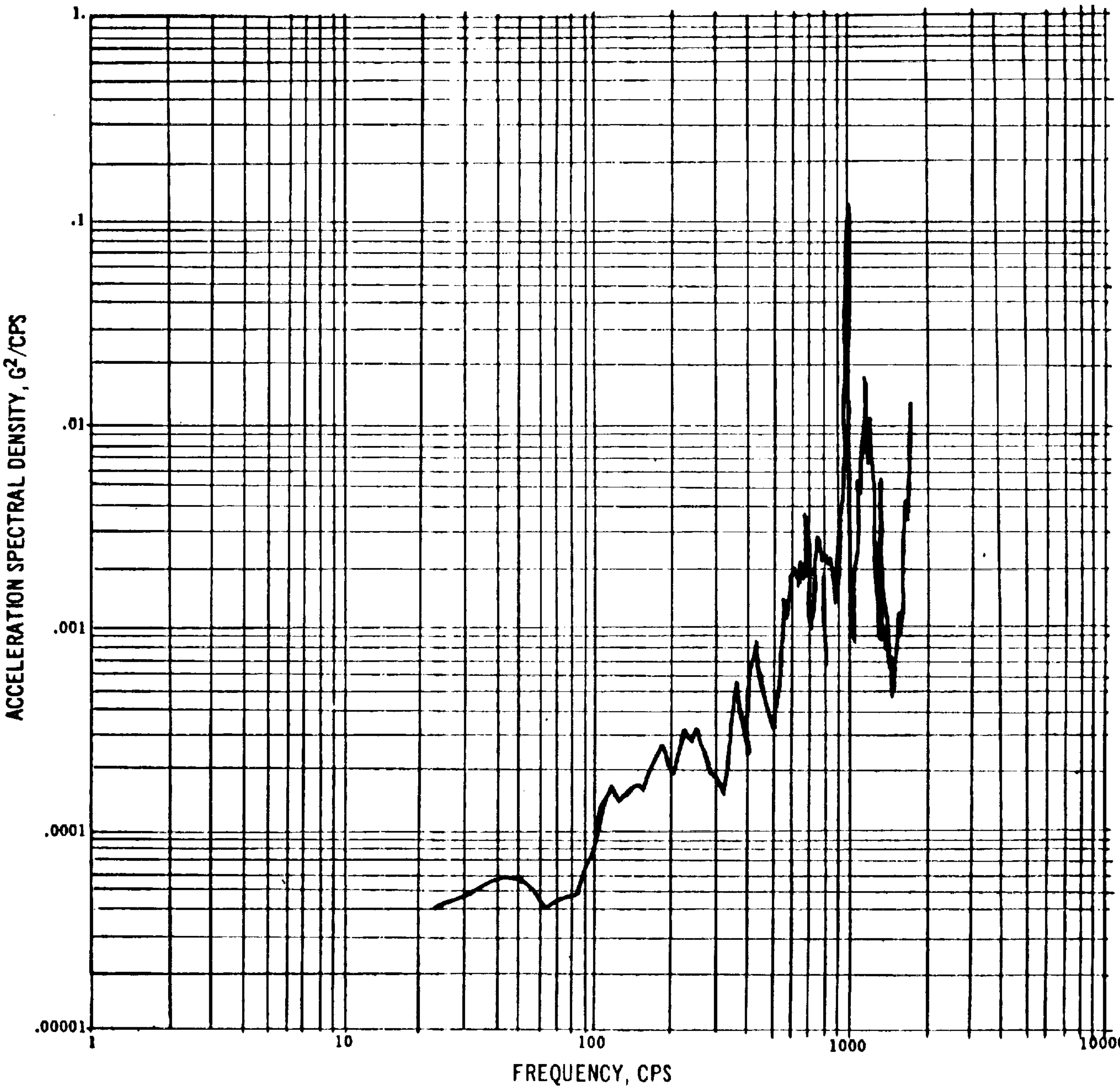


FIGURE 19 e

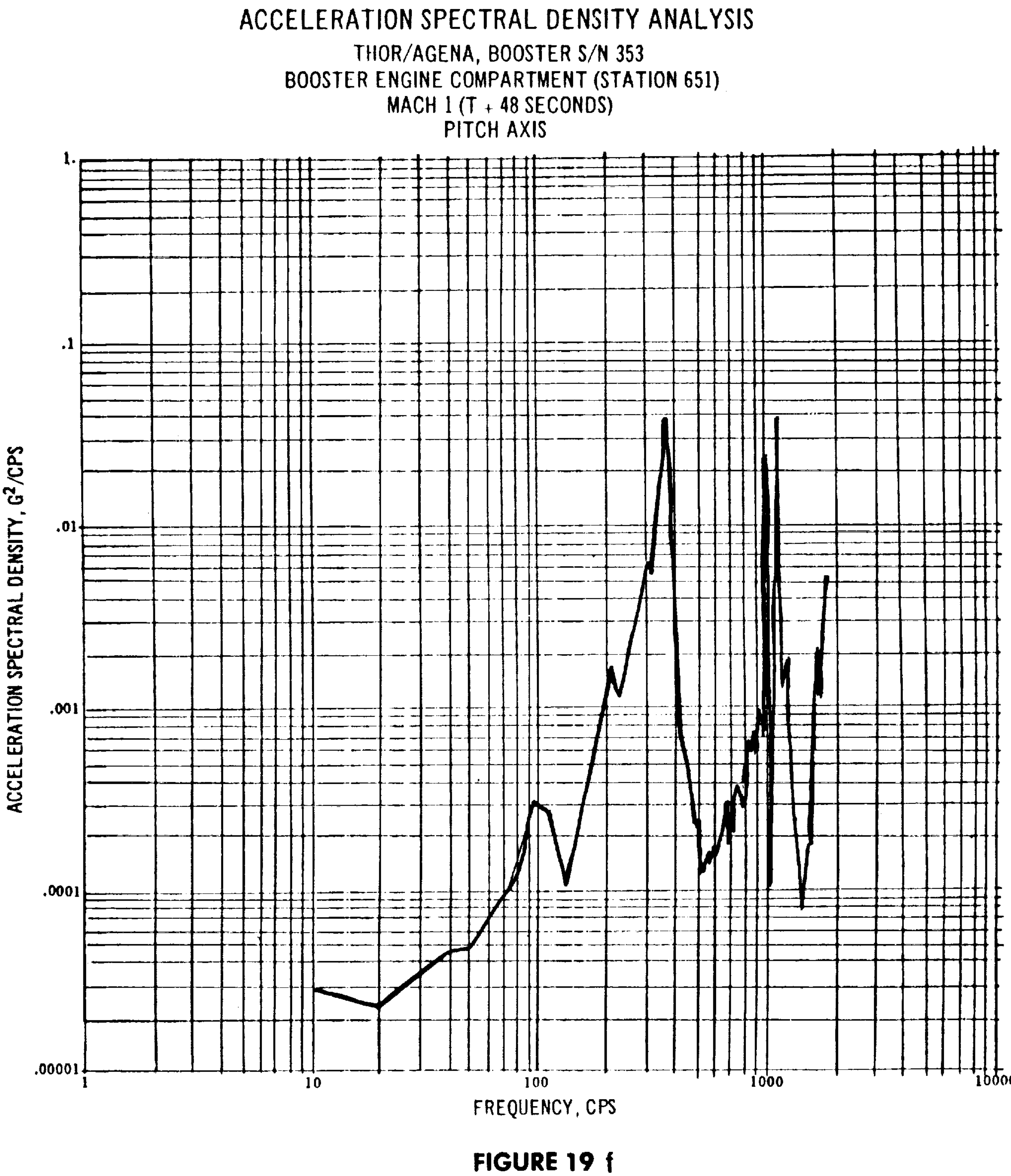

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
MACH 1 (T + 48 SECONDS)
PITCH AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
1.
.1
.01
.001
.0001
.00001
1
10
100
1000
10000
FREQUENCY, CPS

FIGURE 19 f

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF MAXIMUM DYNAMIC PERSSURE
(T + 62 SECONDS)
THRUST AXIS

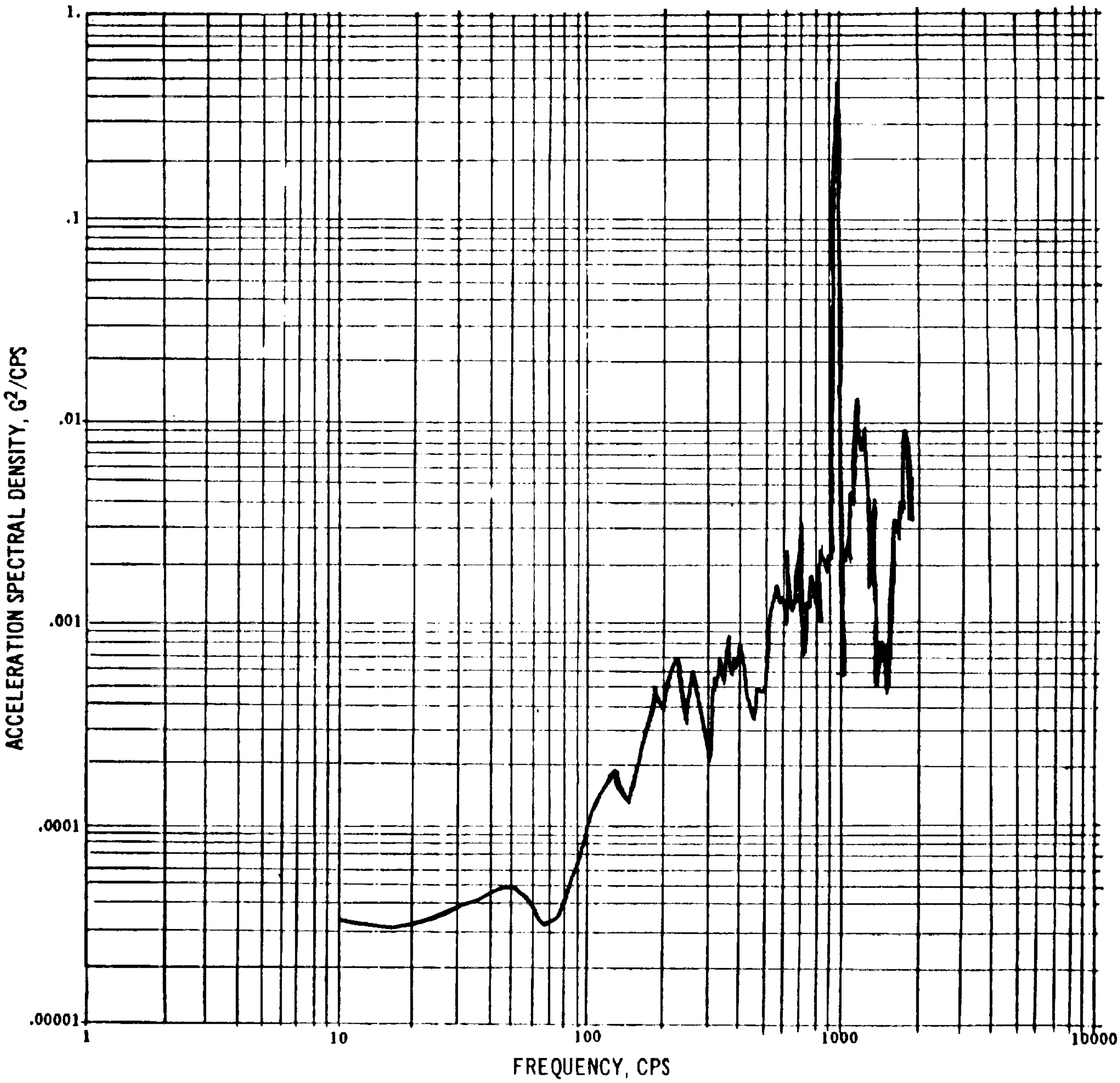


FIGURE 19 g

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF MAXIMUM DYNAMIC PRESSURE
(T + 62 SECONDS)
PITCH AXIS

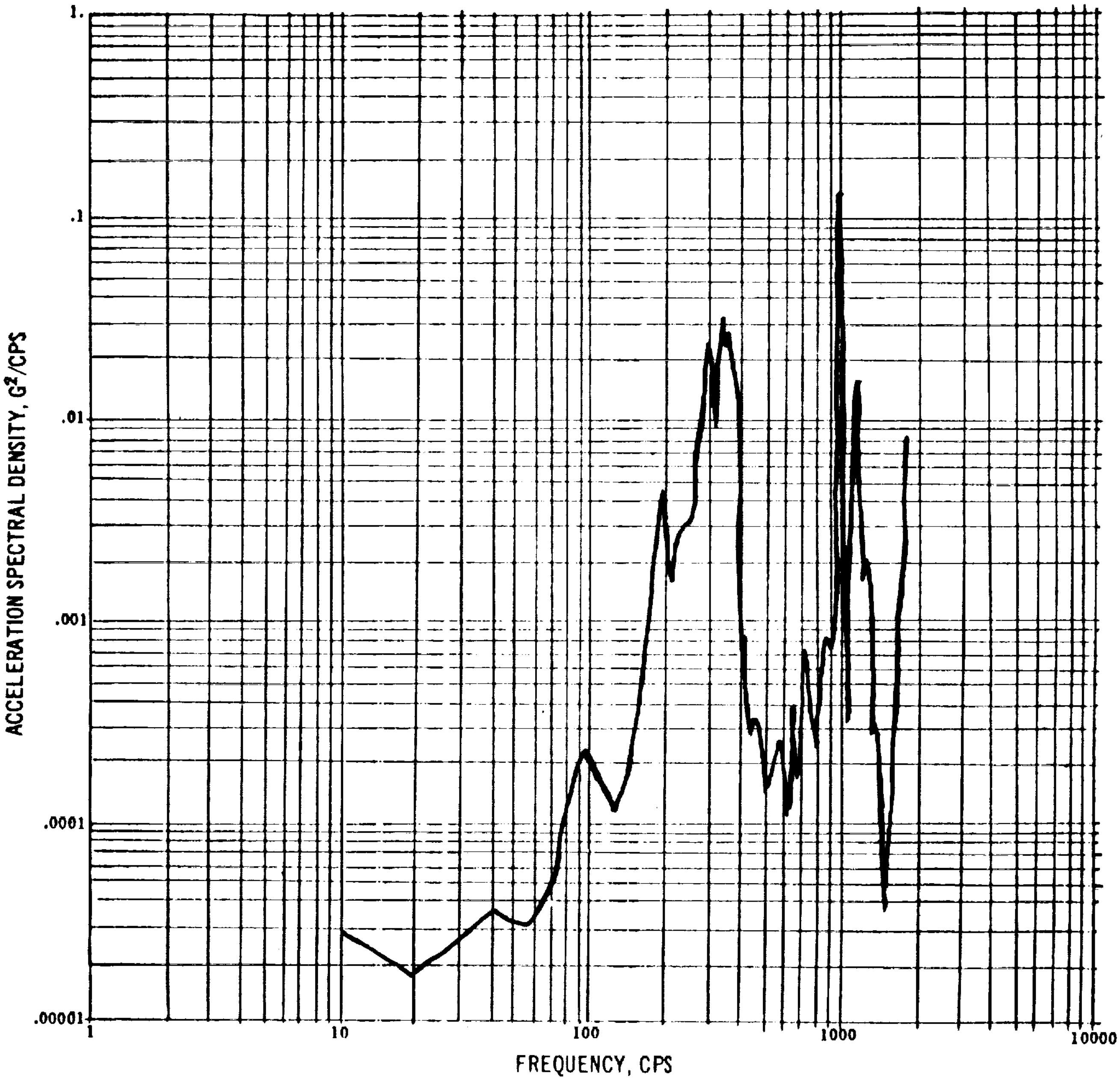


FIGURE 19 h

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
STEADY STATE BURNING PERIOD (T + 110 SECONDS)
THRUST AXIS

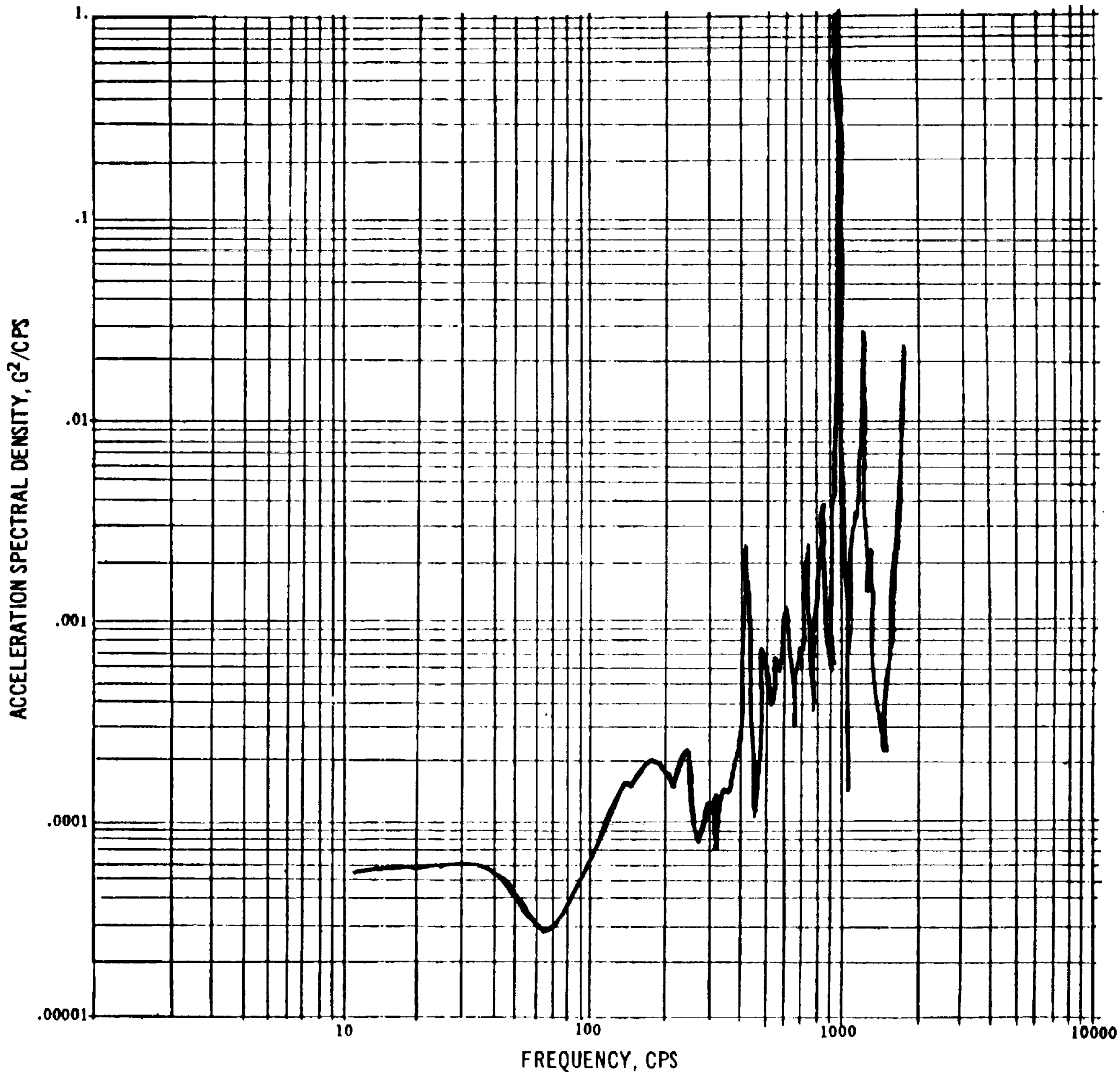


FIGURE 19 i

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
STEADY STATE BURNING PERIOD (T + 110 SECONDS)
PITCH AXIS

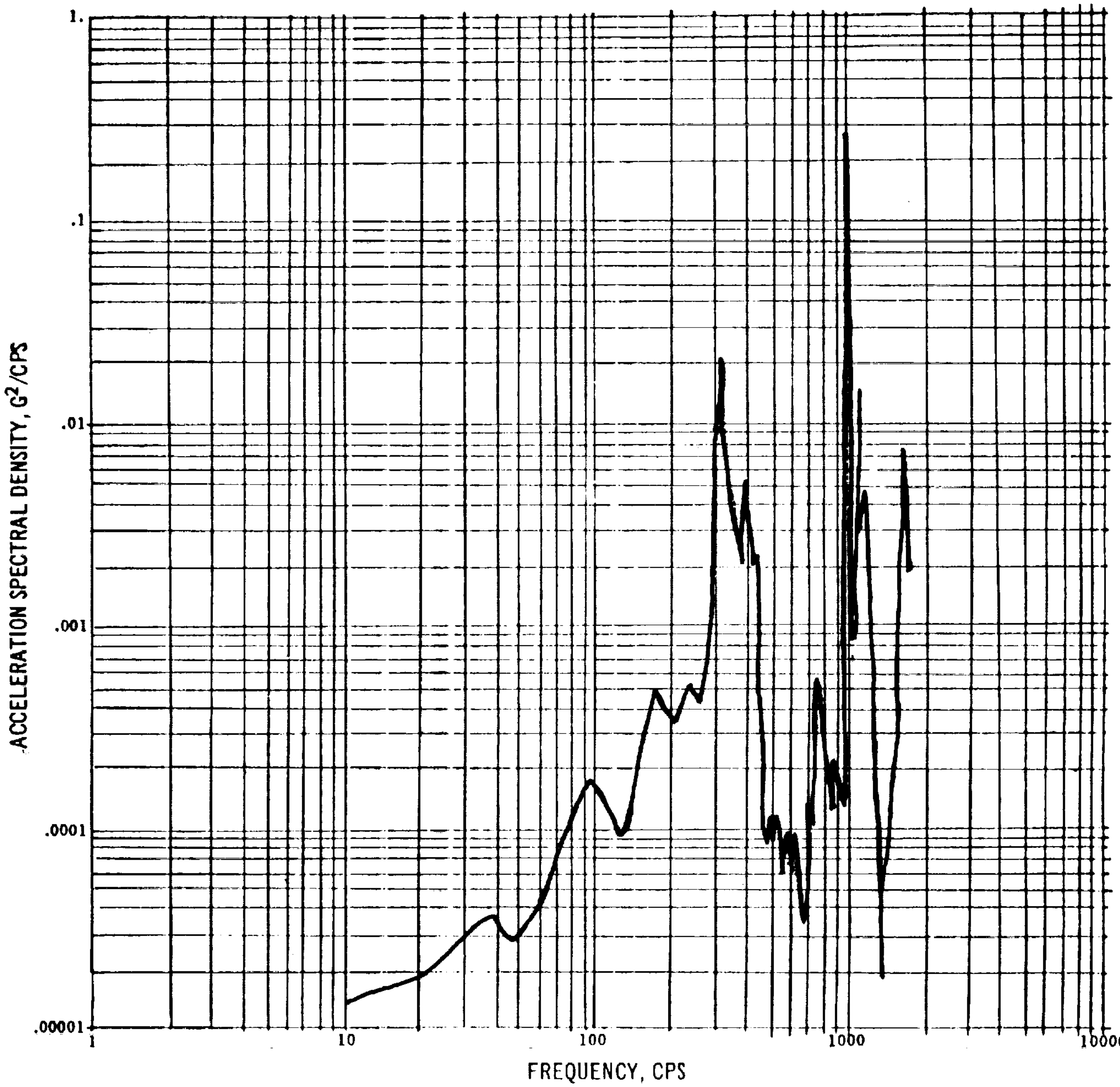


FIGURE 19 j

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF 20 CPS OSCILLATION (T + 141 SECONDS)
THRUST AXIS

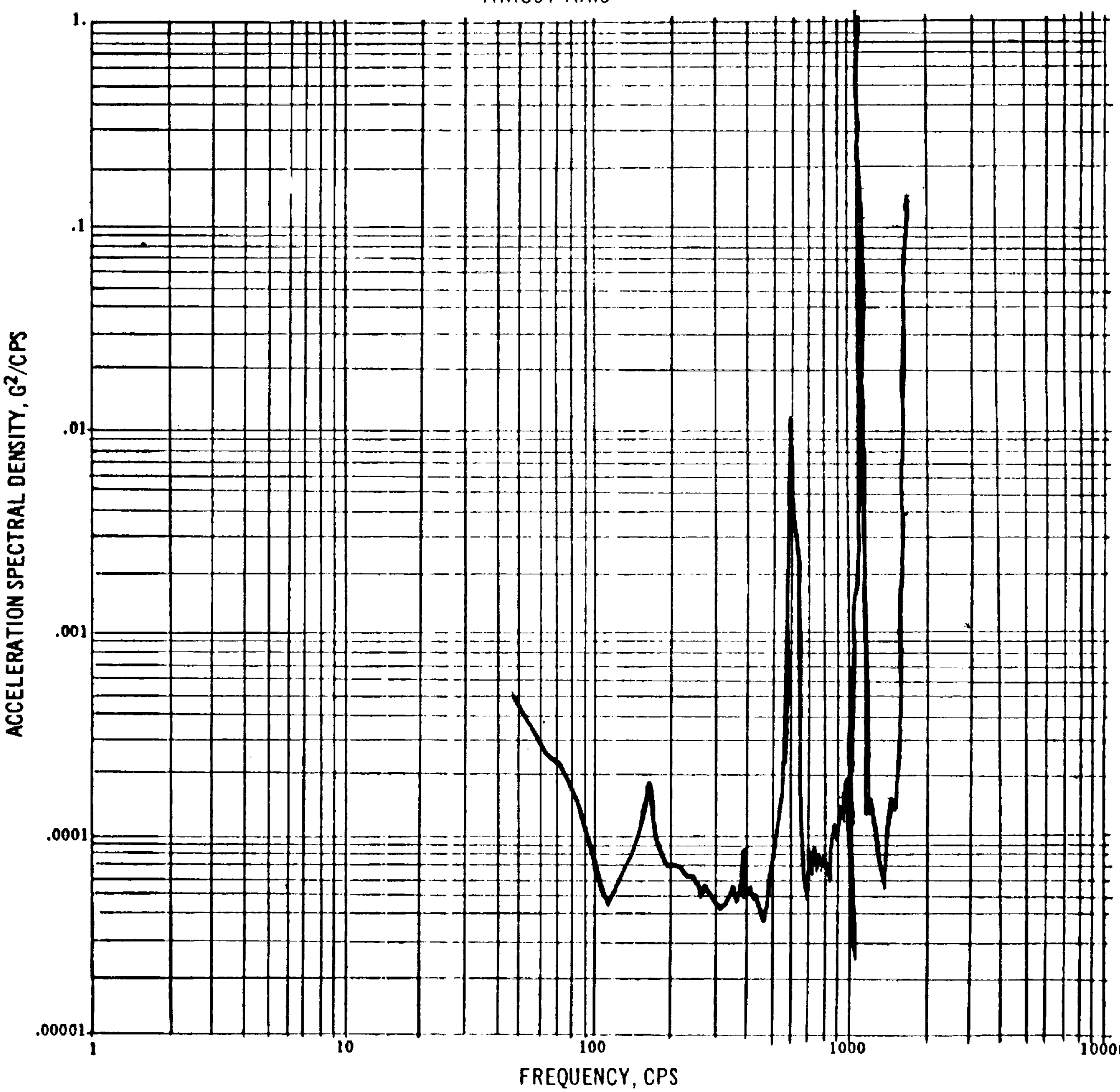


FIGURE 19 k

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/AGENA, BOOSTER S/N 353
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF 20 CPS OSCILLATION (T + 141 SECONDS)
PITCH AXIS

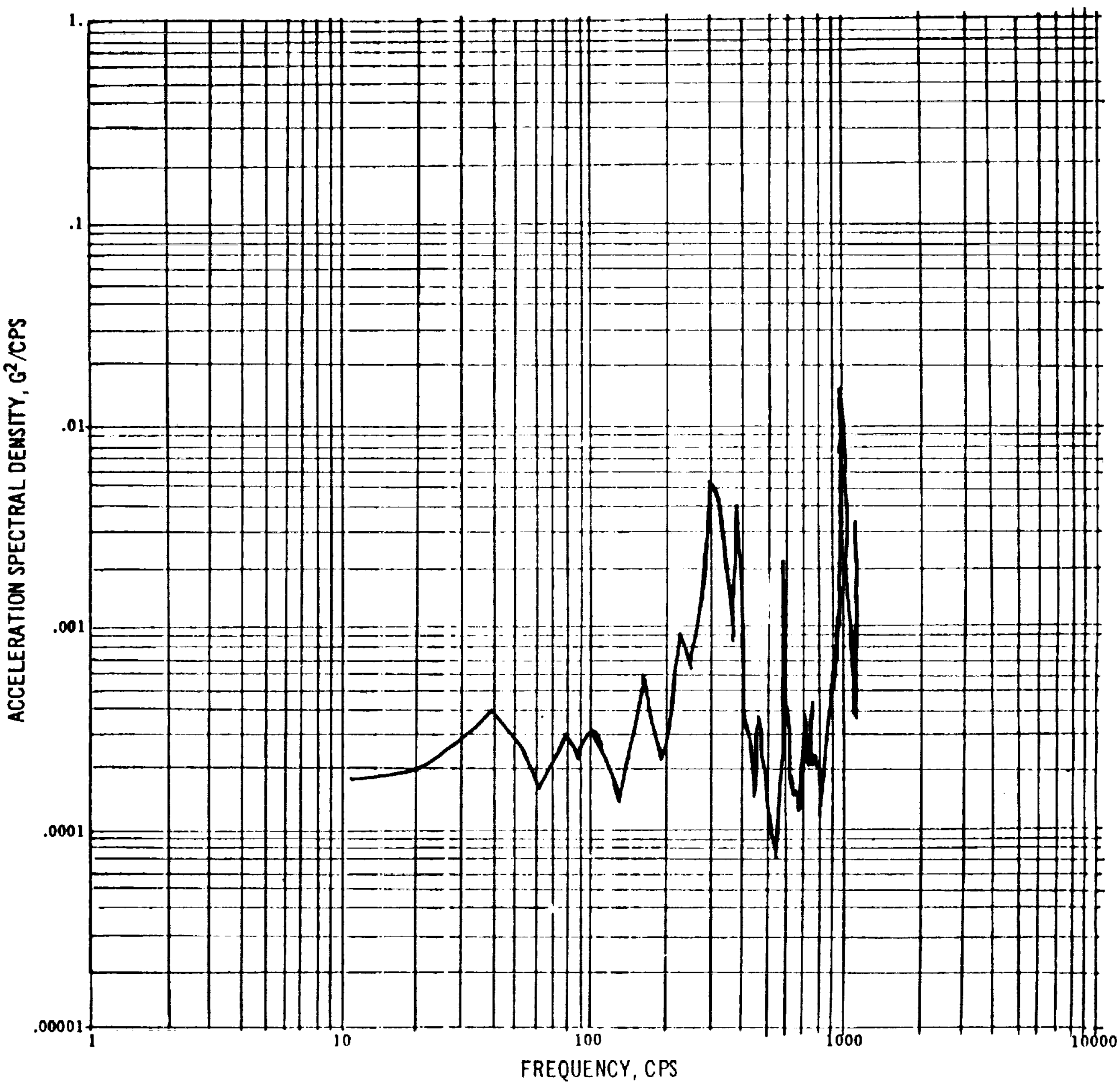


FIGURE 19

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
LIFTOFF PERIOD
THRUST AXIS

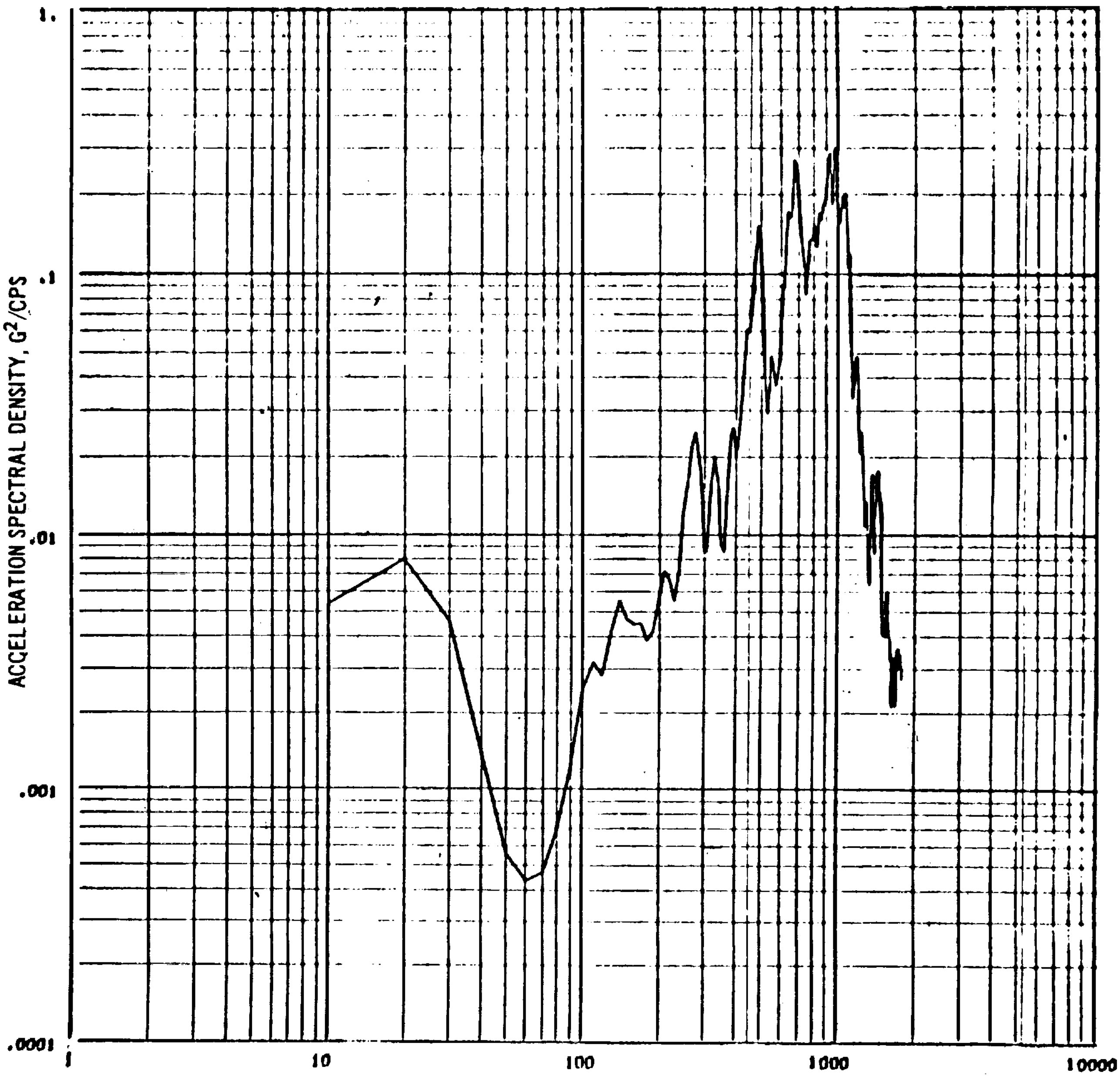


FIGURE 20 a

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR AGENA. BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
LIFTOFF PERIOD
PITCH AXIS

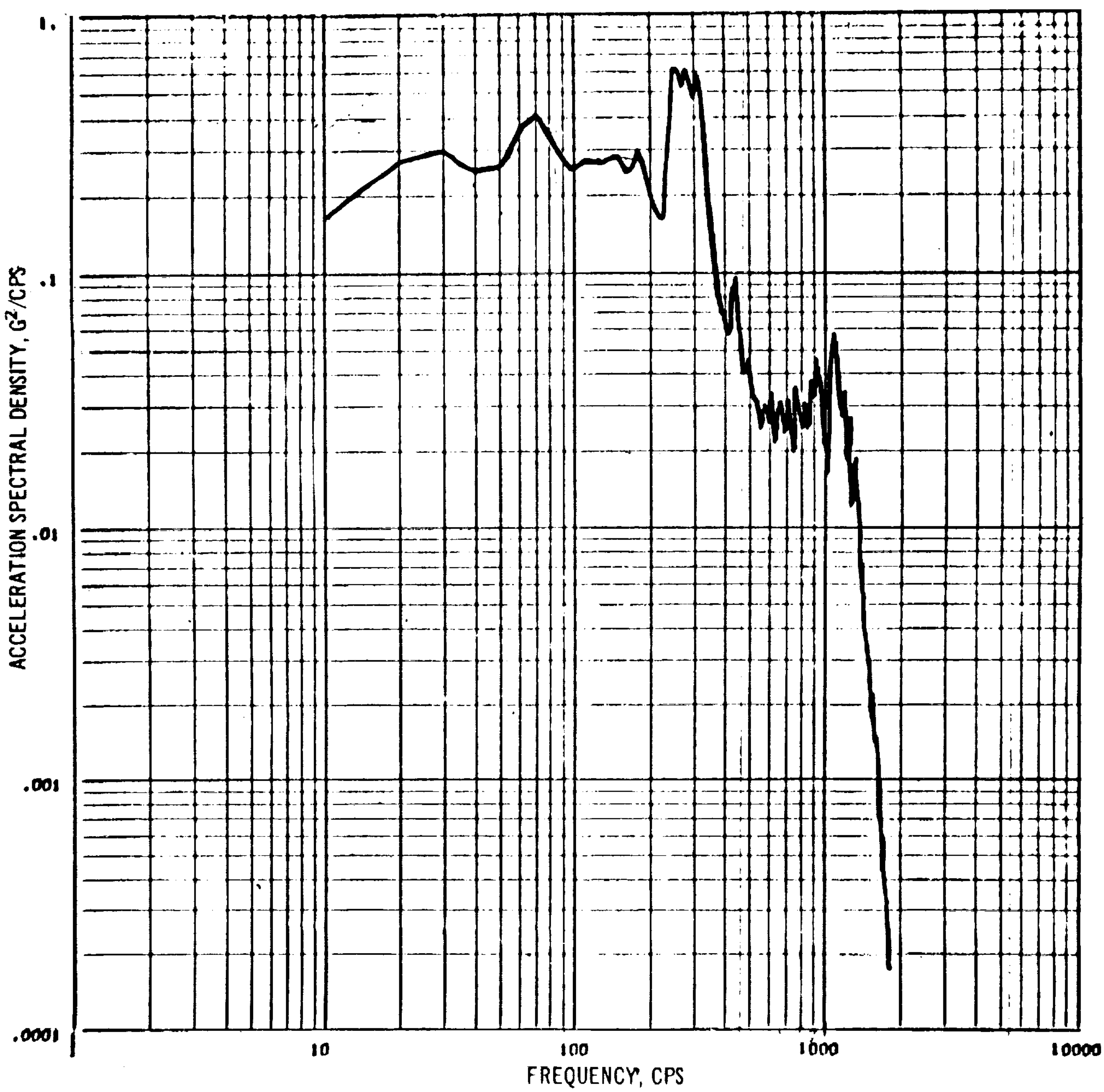


FIGURE 20 b

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
SUBSONIC FLIGHT (T + 20 SECONDS)
THRUST AXIS

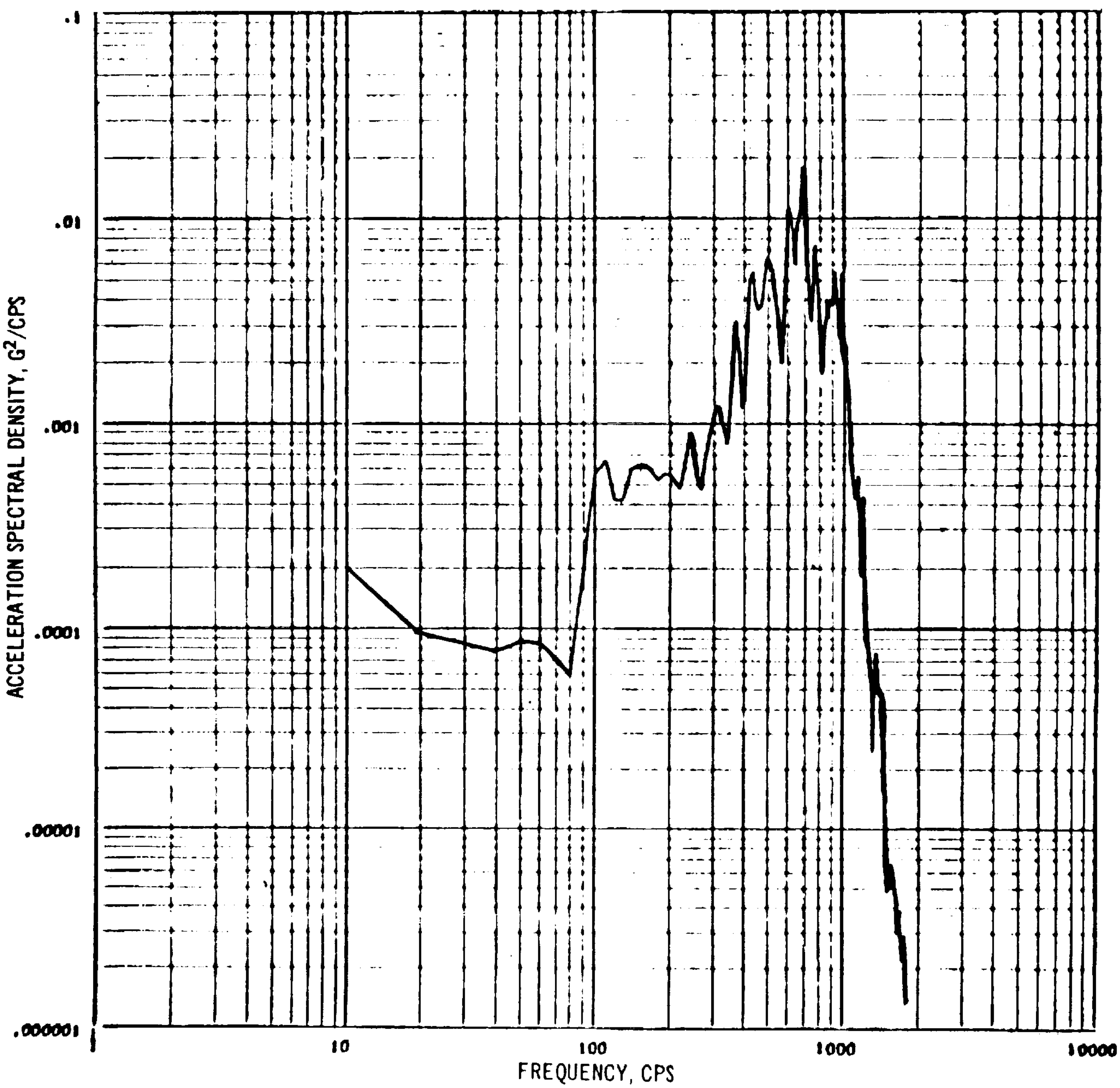


FIGURE 20 C

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
SUBSONIC FLIGHT (T + 20 SECONDS)
PITCH AXIS

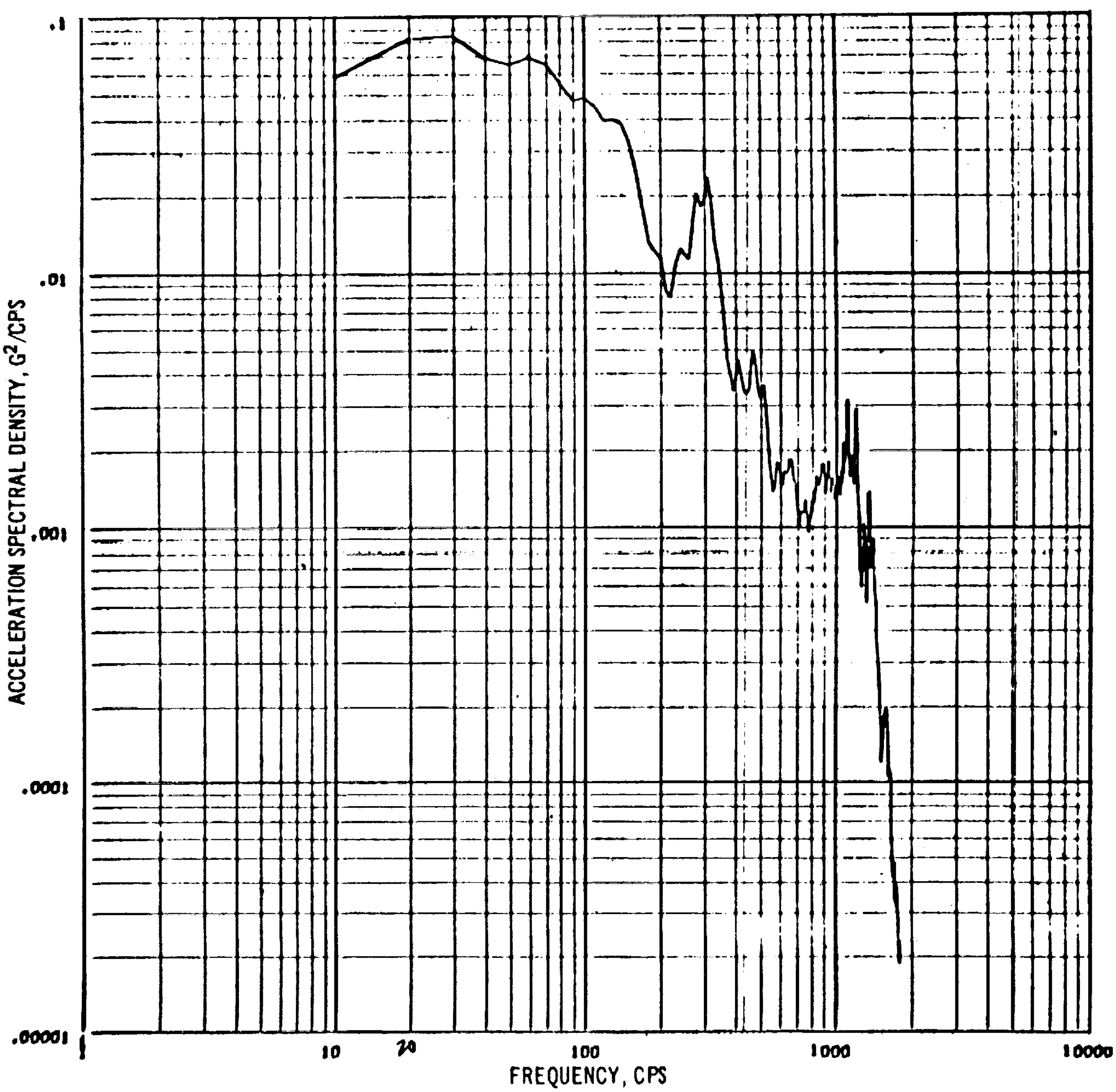


FIGURE 20 d

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF 20 CPS OSCILLATIONS (T + 142 SECONDS)
THRUST AXIS

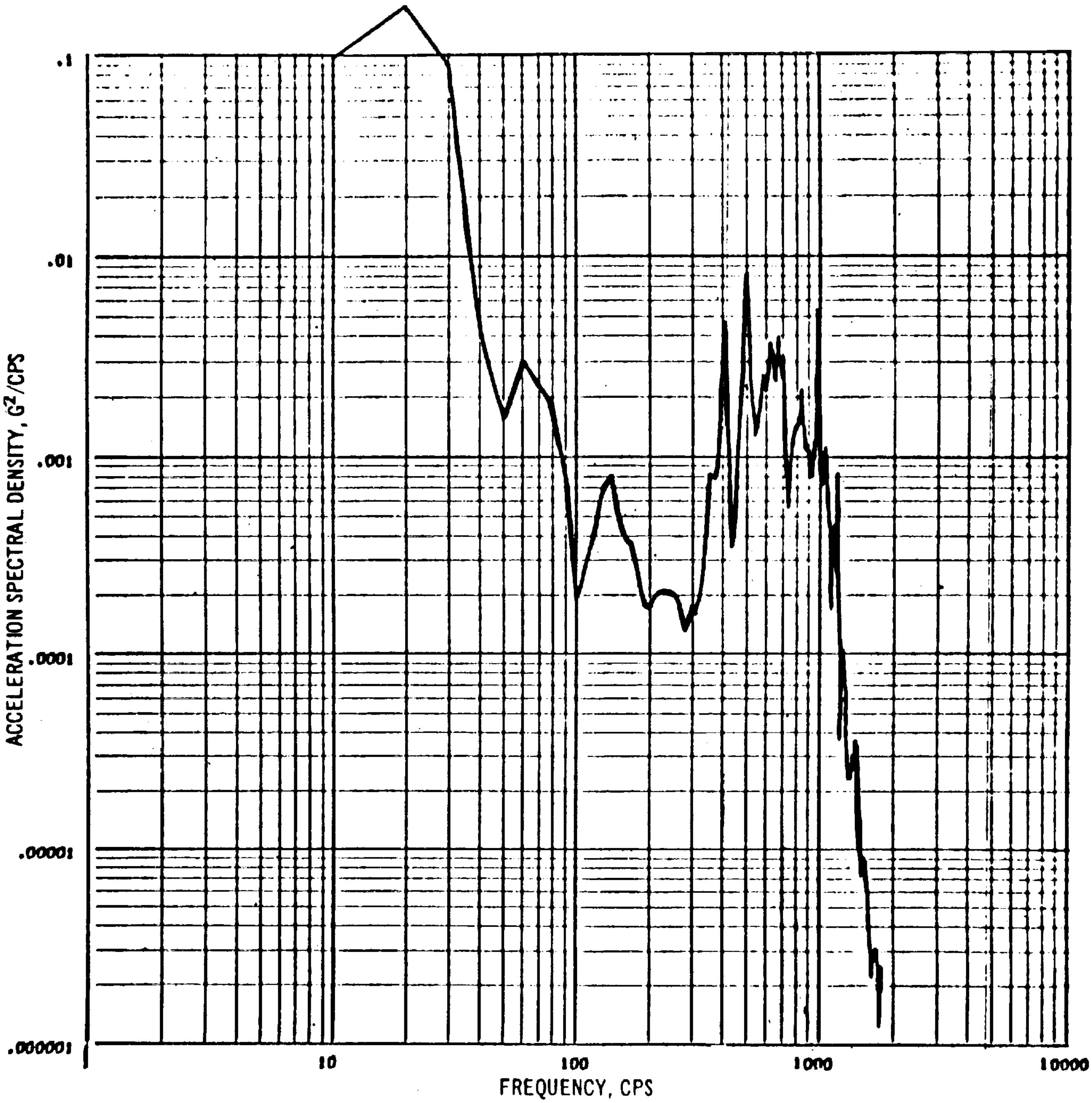


FIGURE 20 e

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
PERIOD OF 20 CPS OSCILLATION (T + 142 SECONDS)
PITCH AXIS

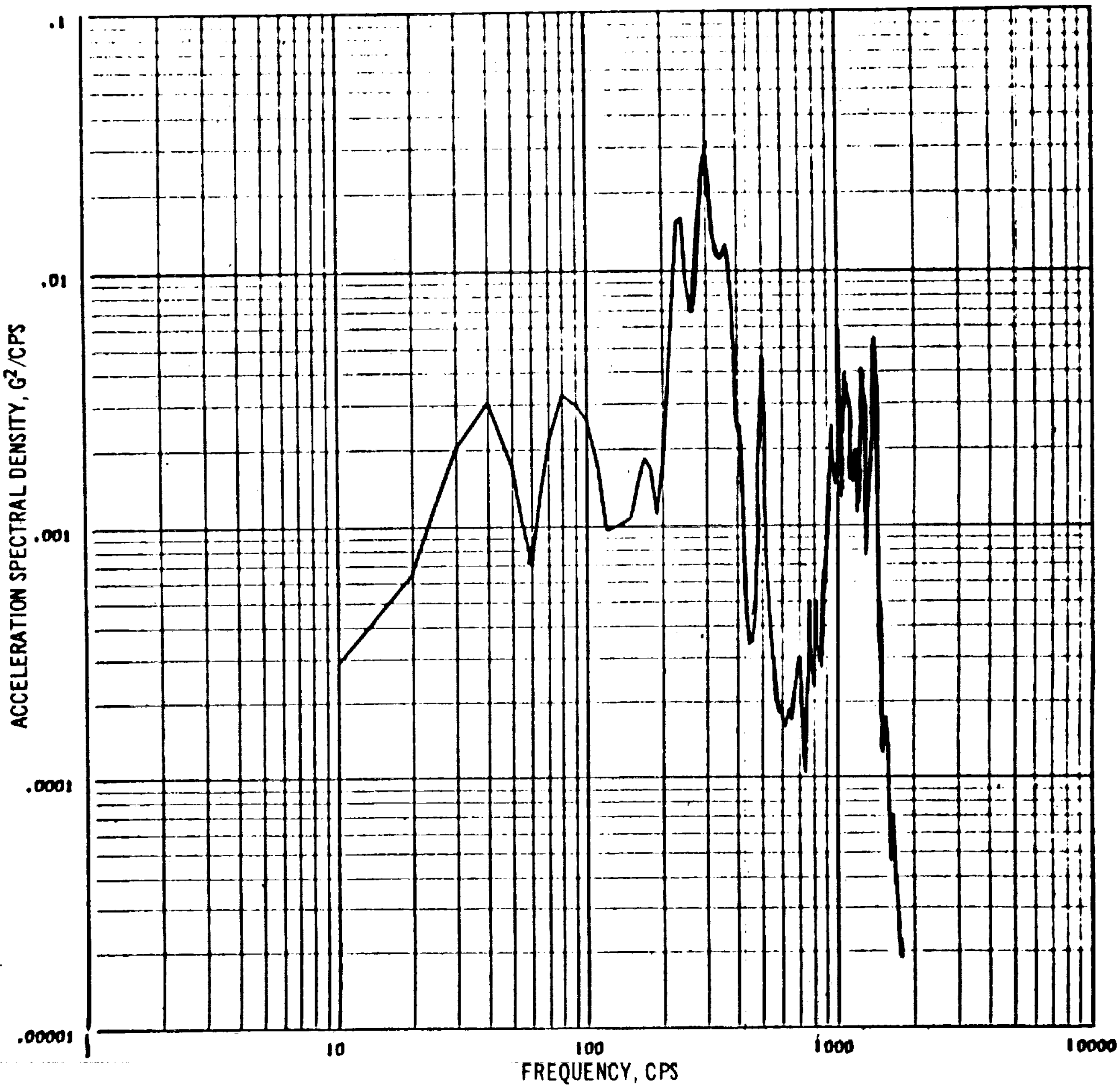


FIGURE 20 f

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR AGENA, BOOSTER S/N 365

BOOSTER ENGINE COMPARTMENT (STATION 651)

SUPERSONIC FLIGHT (T + 110 SECONDS)

THRUST AXIS

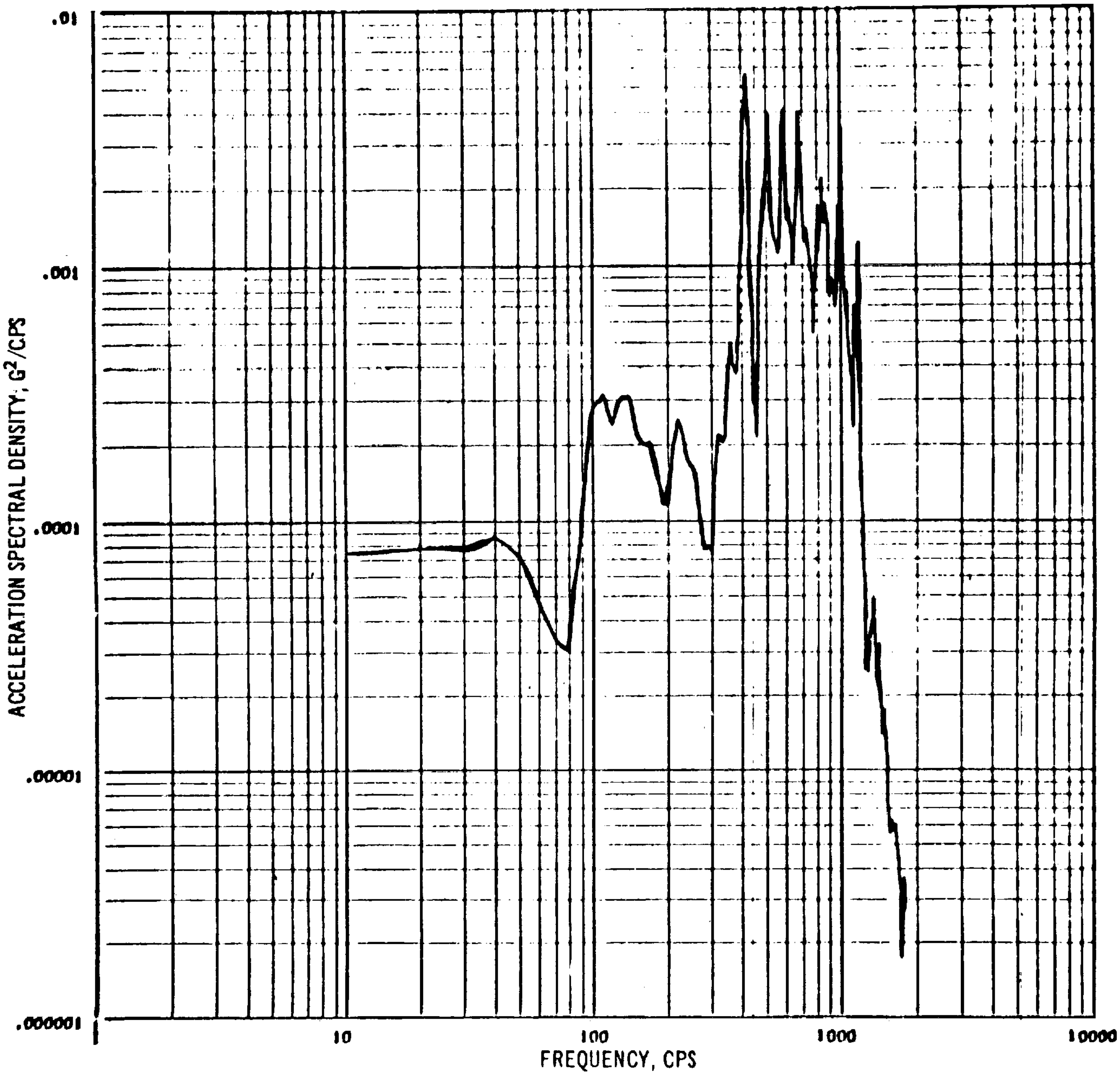


FIGURE 20 g

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR AGENA, BOOSTER S/N 365
BOOSTER ENGINE COMPARTMENT (STATION 651)
SUPERSONIC FLIGHT (T + 110 SECONDS)
PITCH AXIS

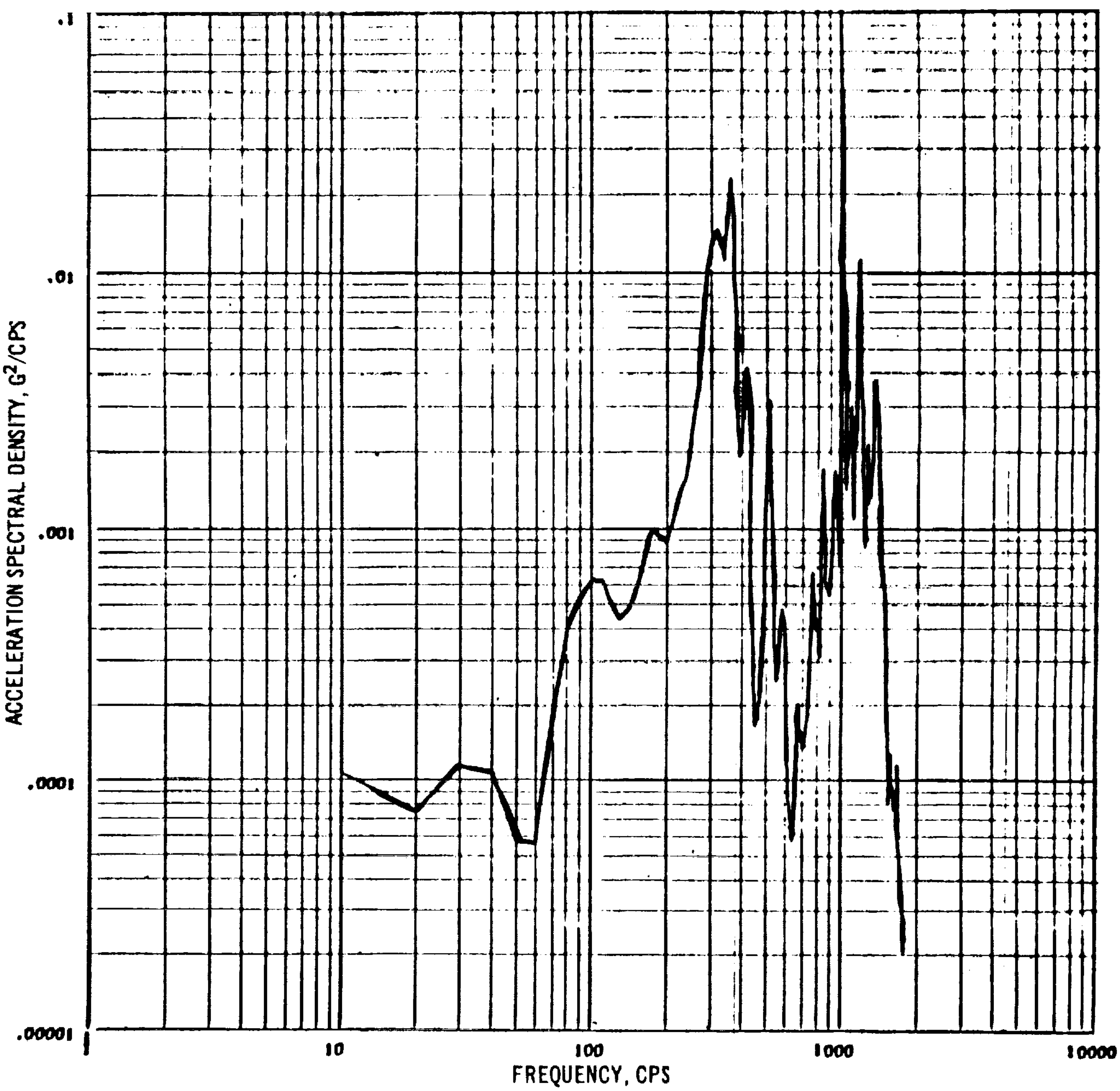


FIGURE 20 h

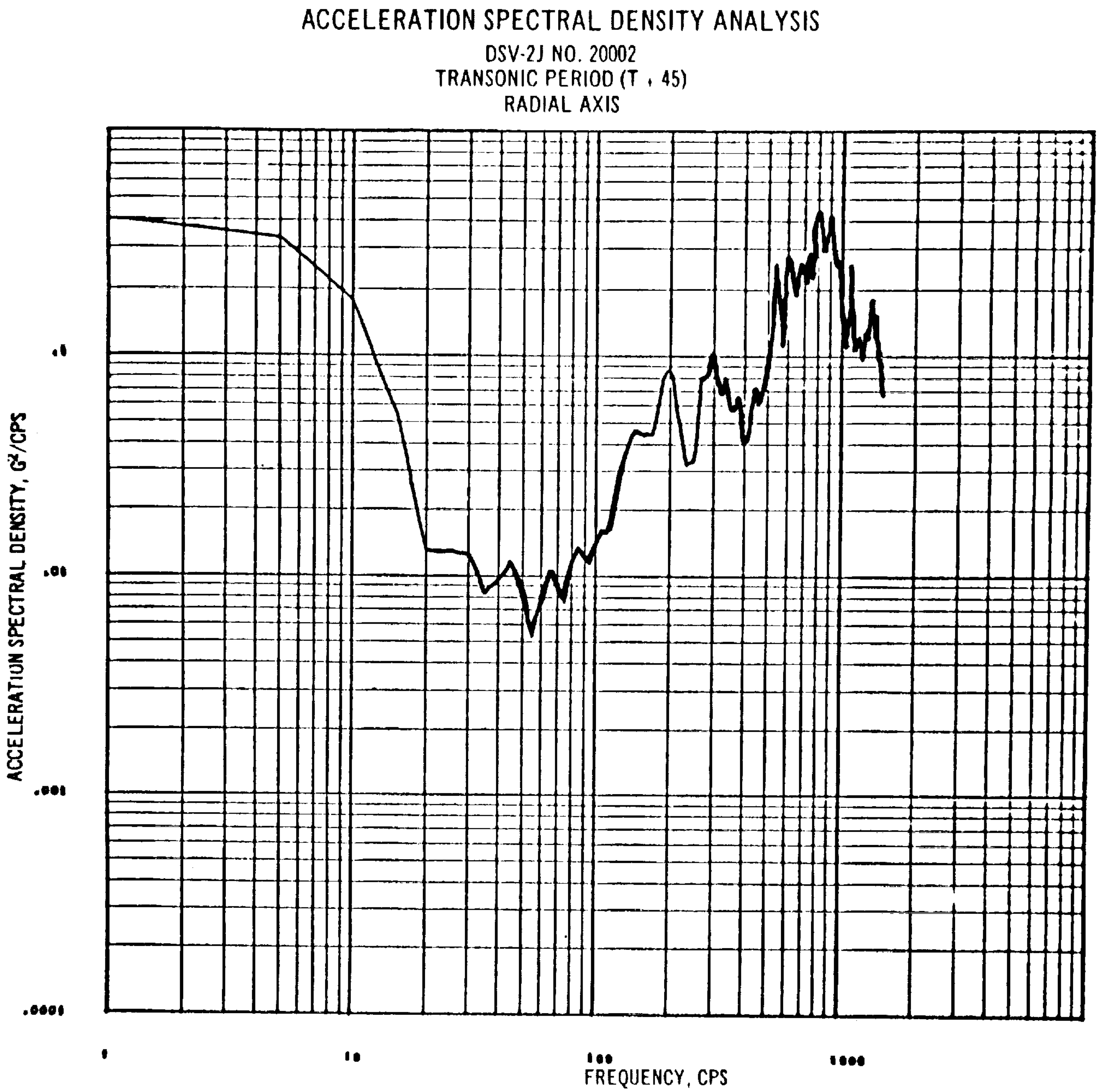
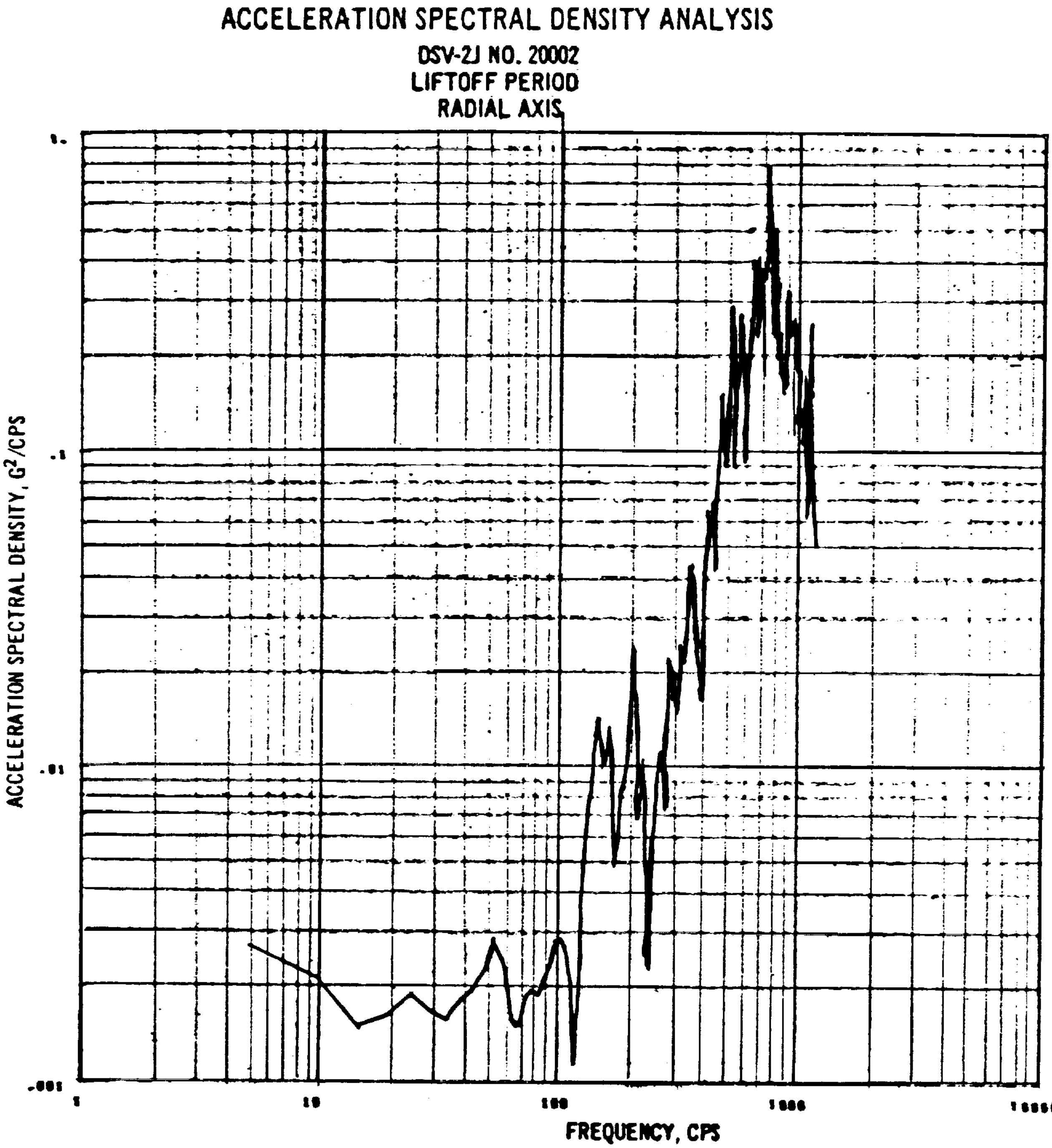

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J NO. 20002
TRANSONIC PERIOD (T + 45)
RADIAL AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
.1
.01
.001
.0001
1
10
100
1000
FREQUENCY, CPS

FIGURE 21a



ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J NO. 20002
LIFTOFF PERIOD
RADIAL AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
FREQUENCY, CPS

FIGURE 21 b

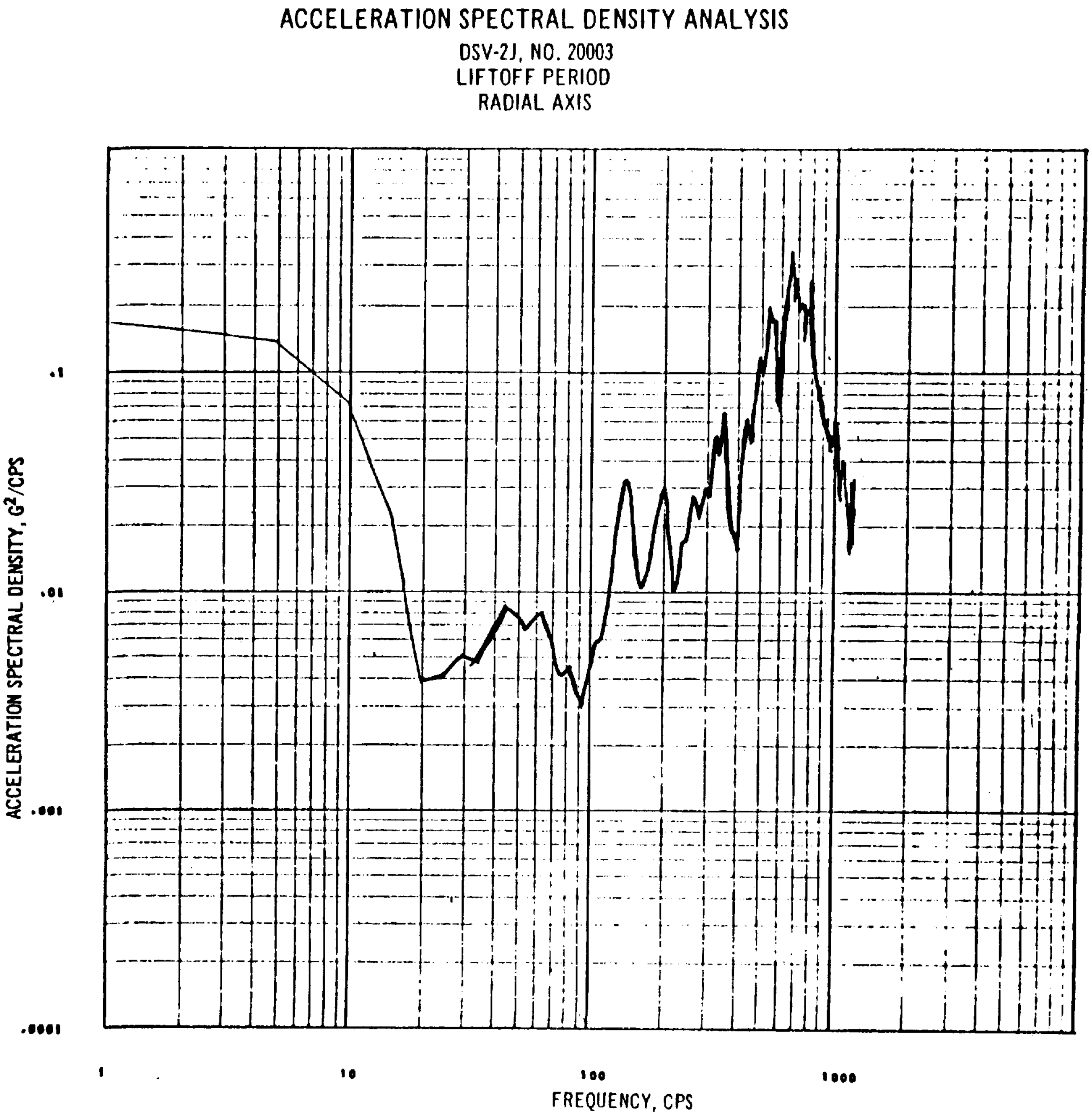

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J, NO. 20003
LIFTOFF PERIOD
RADIAL AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
.1
.01
.001
.0001
1
10
100
1000
FREQUENCY, CPS

FIGURE 22 a

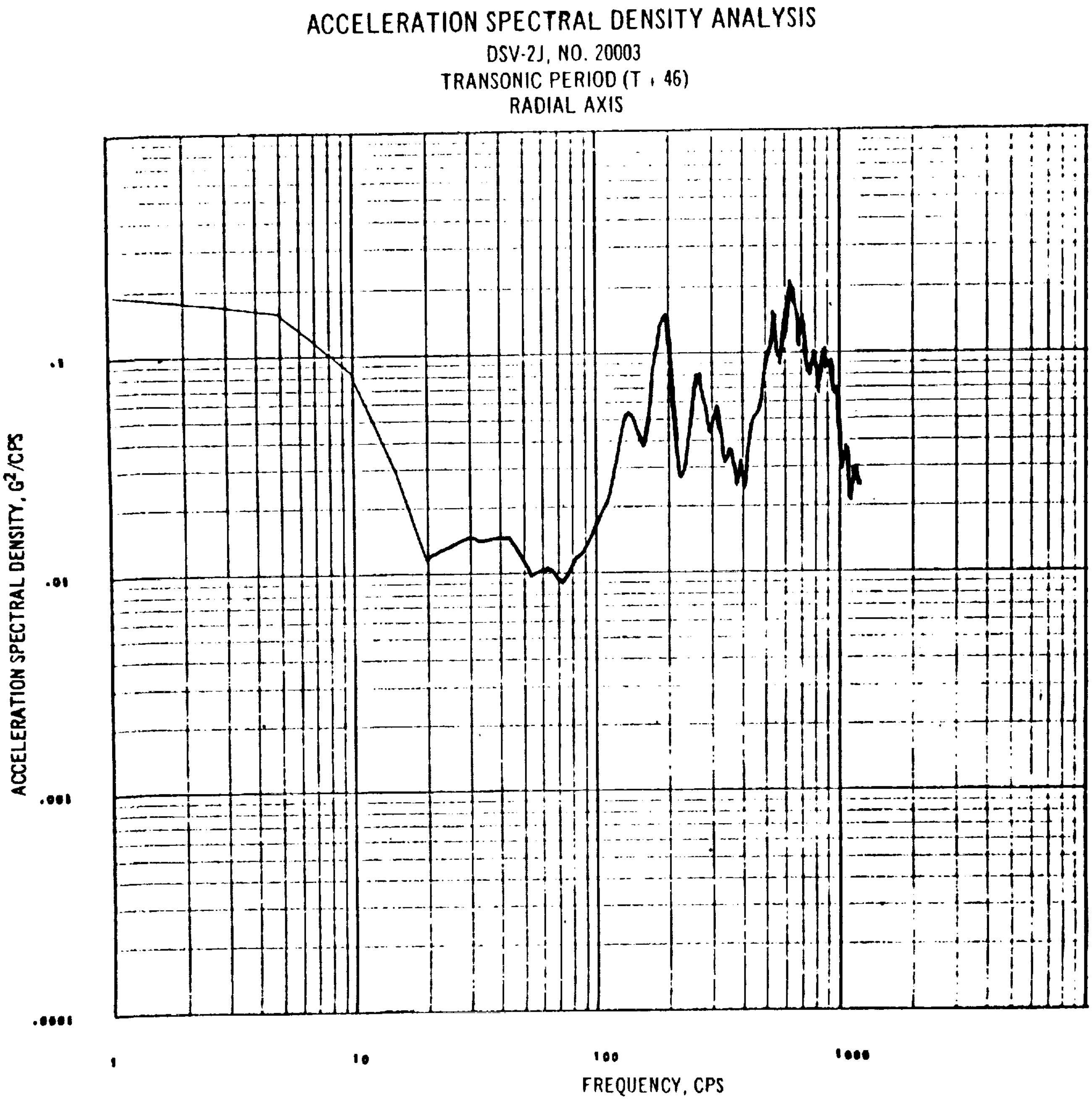

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J, NO. 20003
TRANSONIC PERIOD (T + 46)
RADIAL AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
.1
.01
.001
.0001
1
10
100
1000
FREQUENCY, CPS

FIGURE 22 b

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J, NO. 20006
LIFTOFF PERIOD
THRUST AXIS

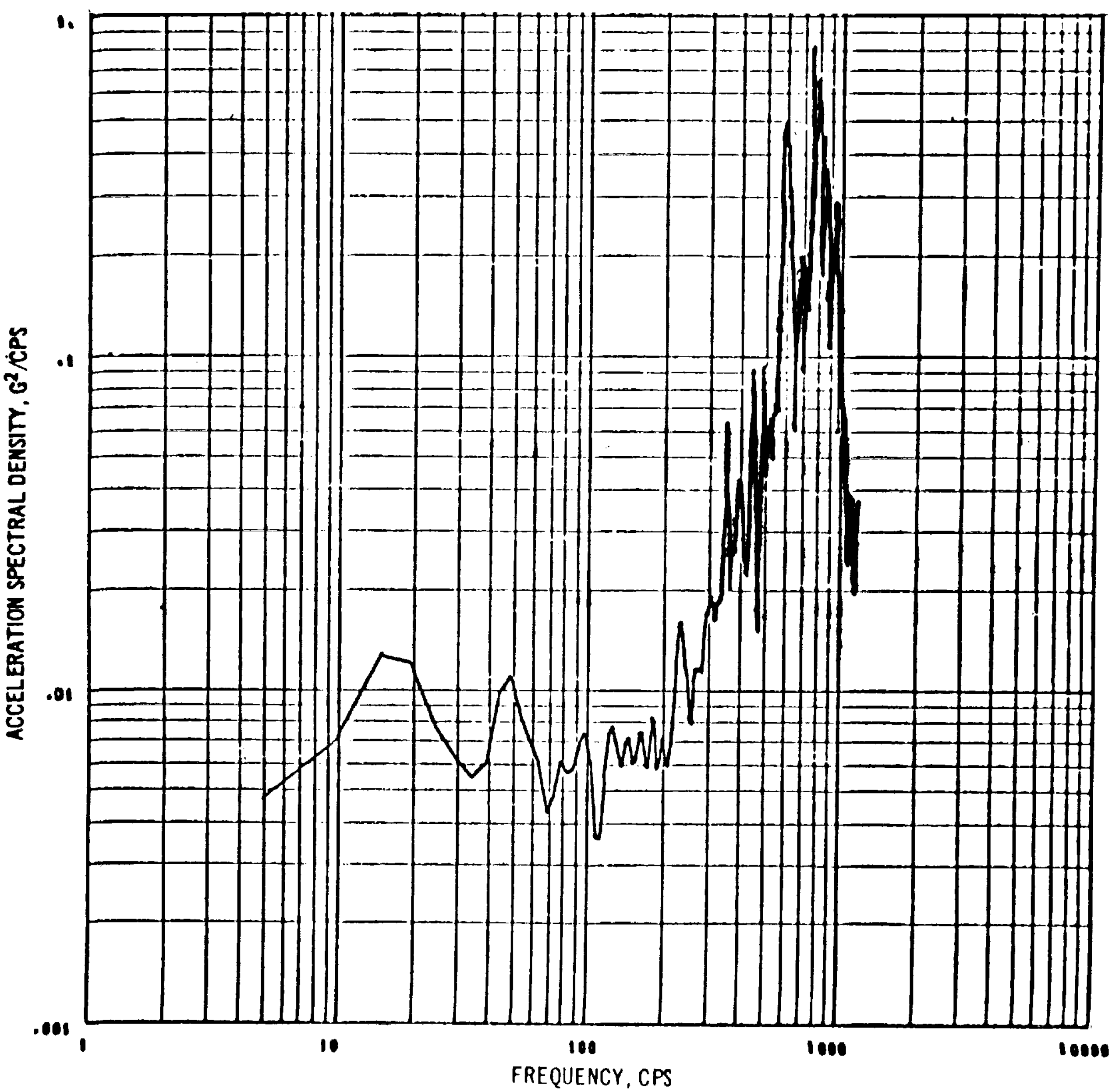


FIGURE 23 a

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J, NO. 20006
LIFTOFF PERIOD
RADIAL AXIS

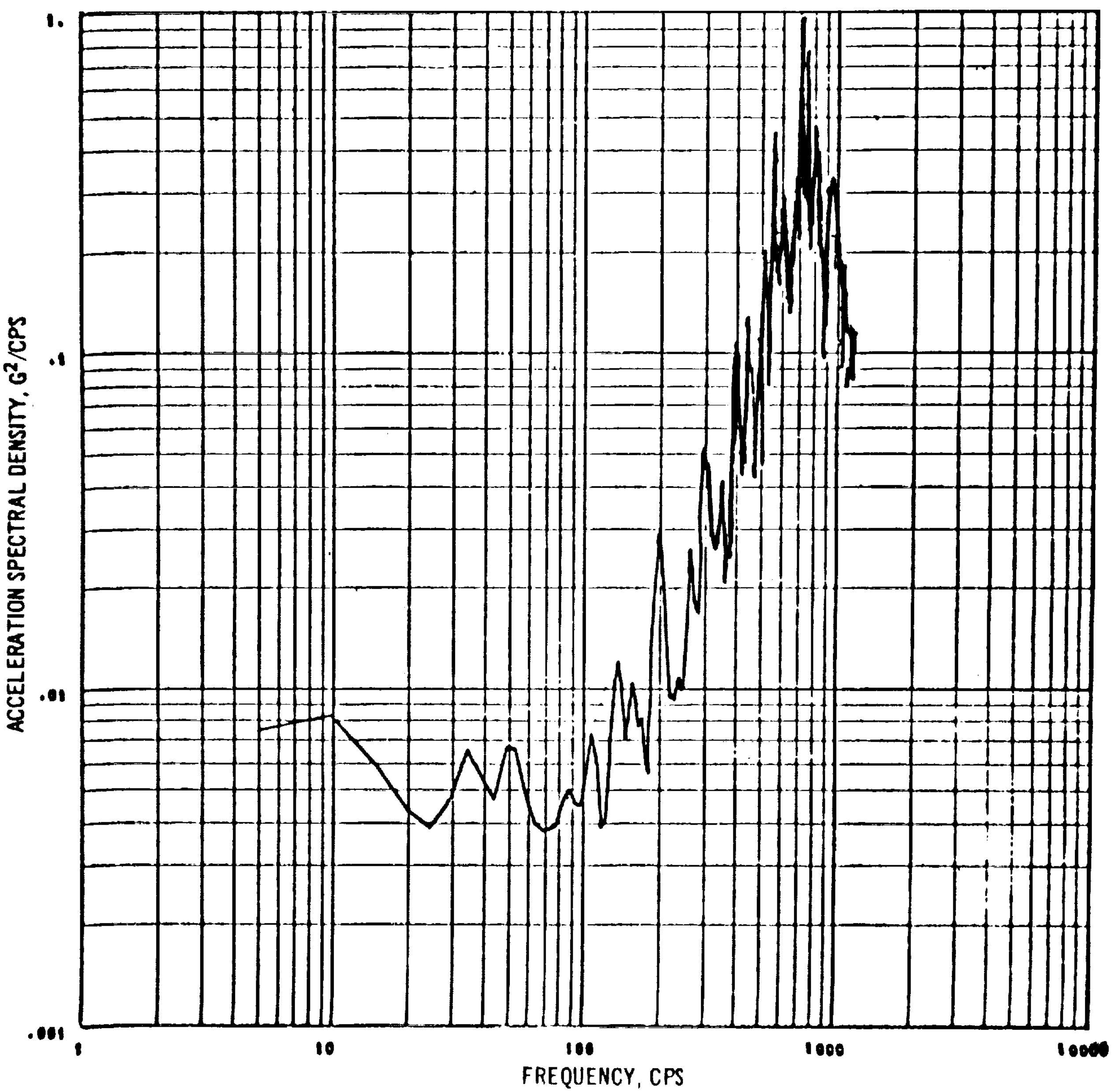


FIGURE 23 b

ACCELERATION SPECTRAL DENSITY ANALYSIS

DSV-2J, NO. 20006

TRANSONIC PERIOD (T + 46)

THRUST AXIS

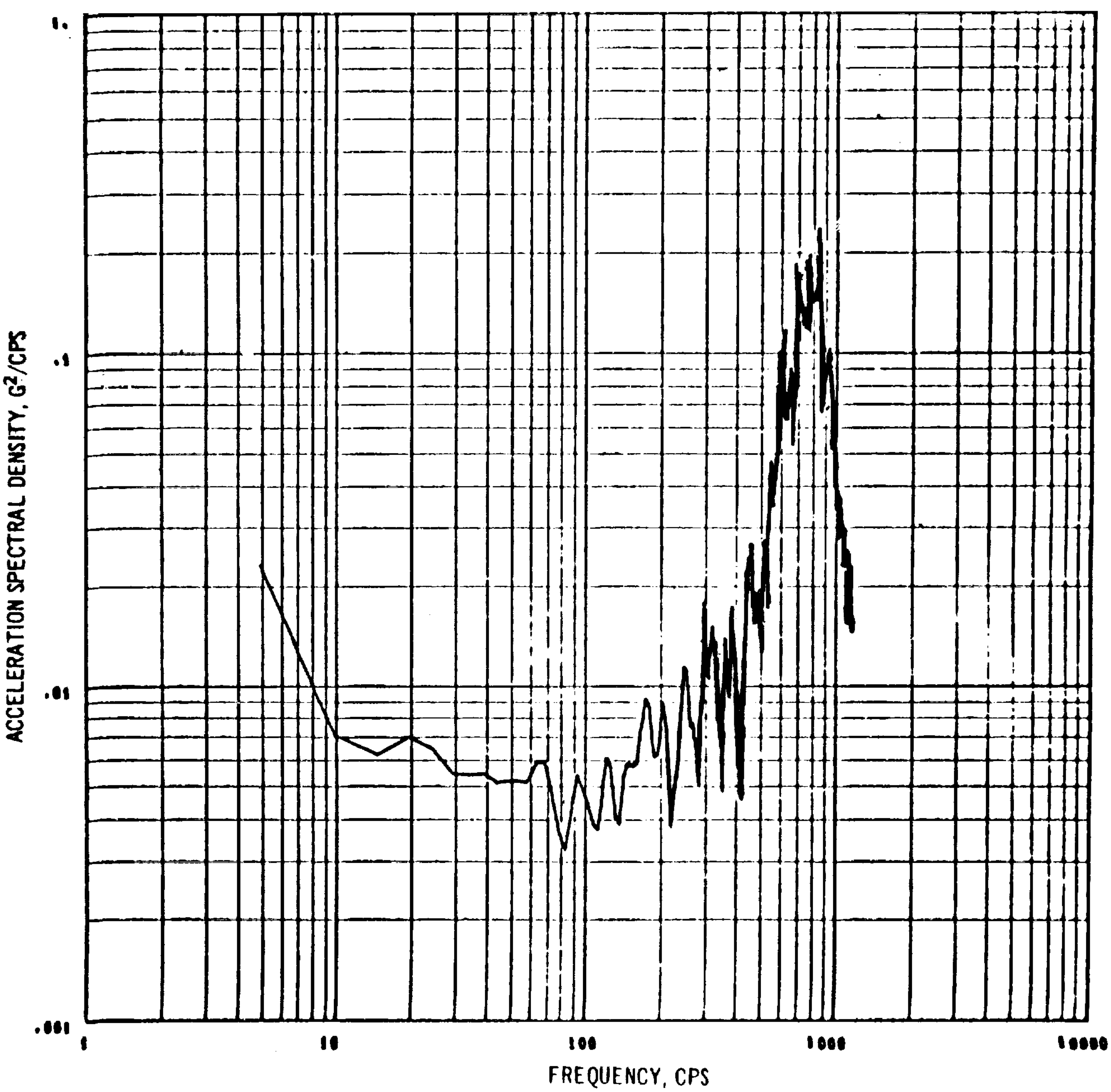


FIGURE 23 C

ACCELERATION SPECTRAL DENSITY ANALYSIS
DSV-2J, NO. 20006
TRANSONIC PERIOD (T + 46)
RADIAL AXIS

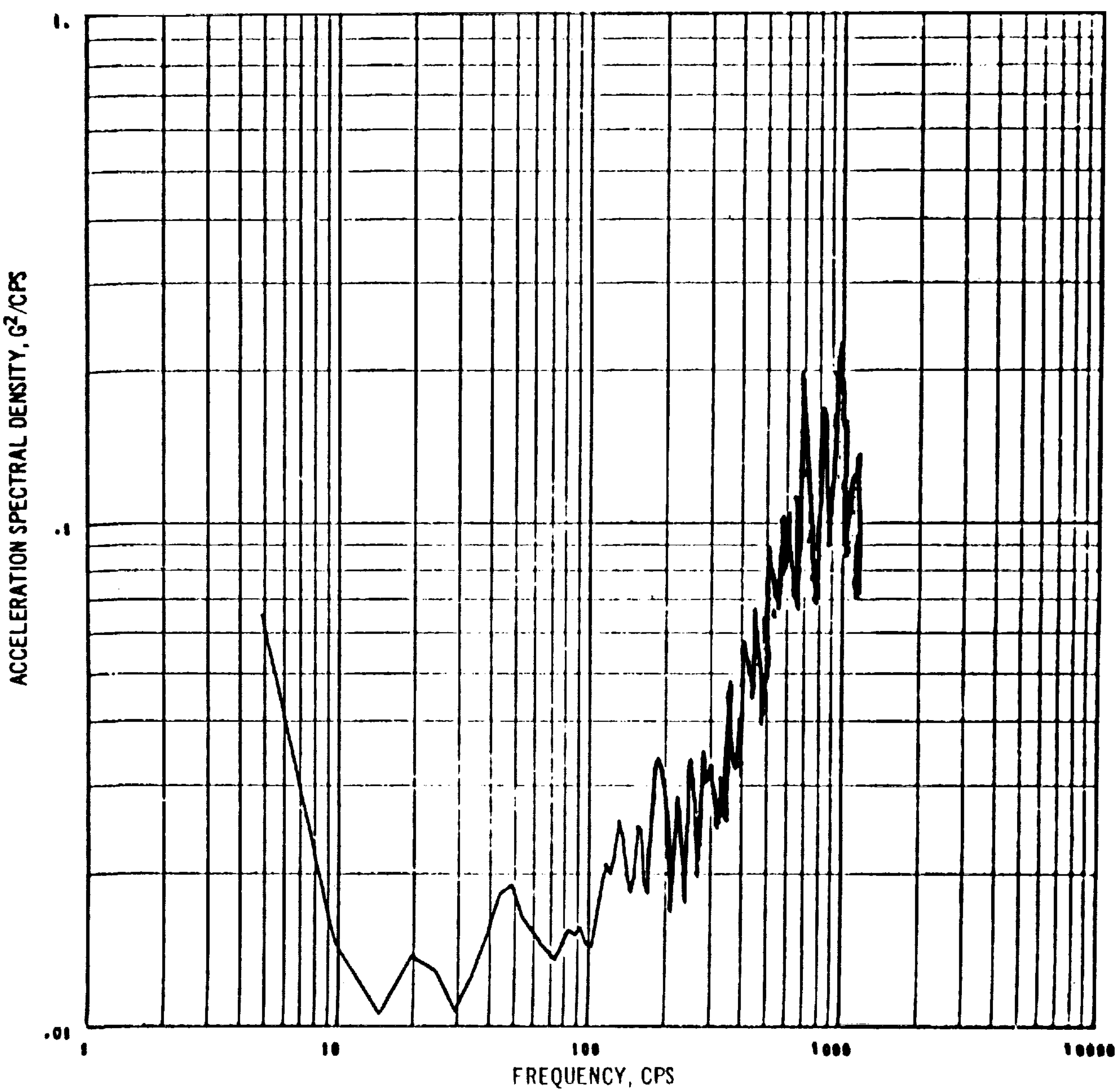


FIGURE 23d

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/ASSET, DSV-2F
(STATION 141)
LIFTOFF PERIOD
THRUST AXIS

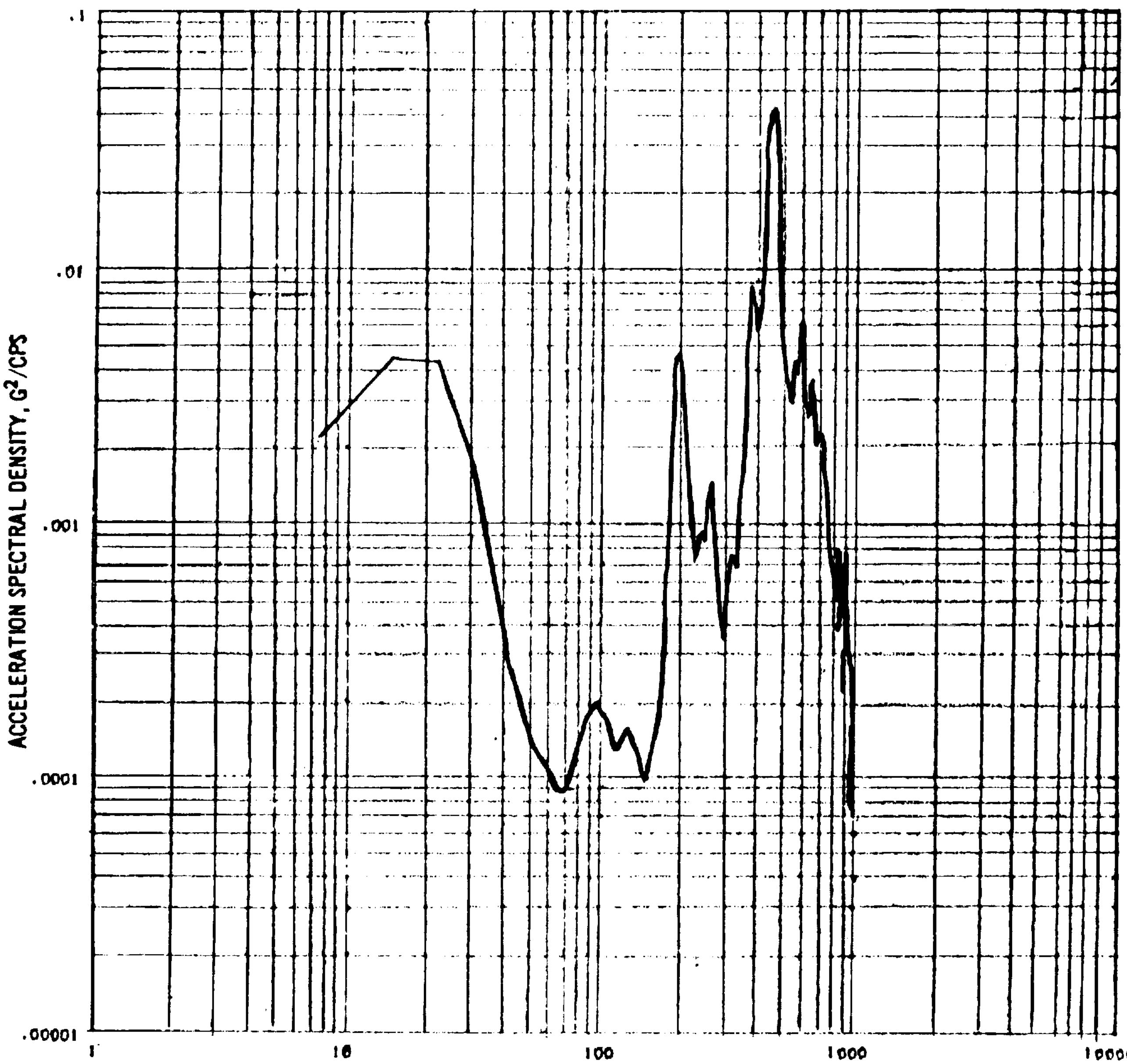


FIGURE 24 a

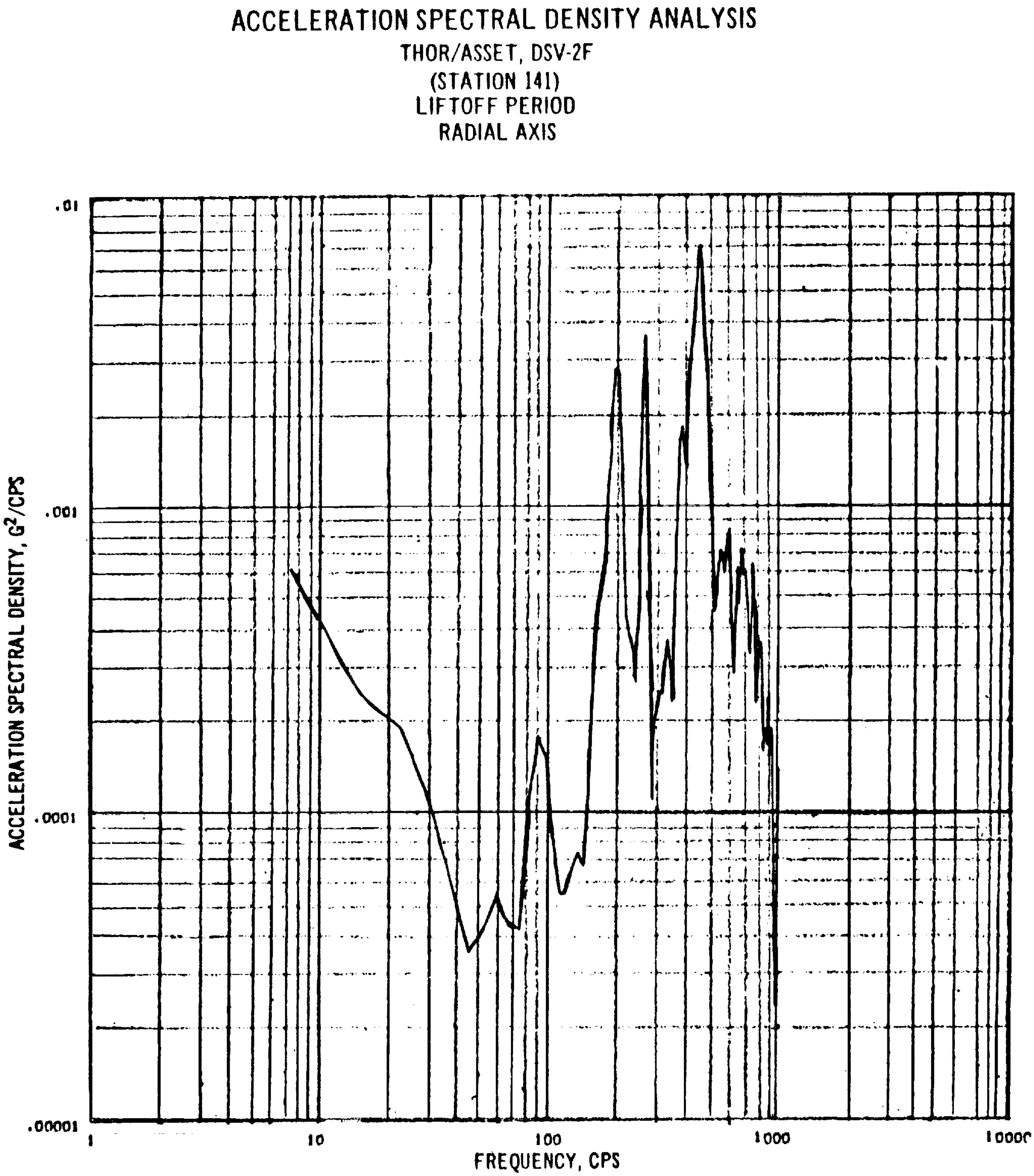

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/ASSET, DSV-2F
(STATION 141)
LIFTOFF PERIOD
RADIAL AXIS
ACCELERATION SPECTRAL DENSITY, G²/CPS
.01
.001
.0001
.00001
1
10
100
1000
10000
FREQUENCY, CPS

FIGURE 24 b

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/ASSET, DSV-2F

(STATION 141)

PERIOD OF MAXIMUM VIBRATION (T + 60 SECONDS)

THRUST AXIS

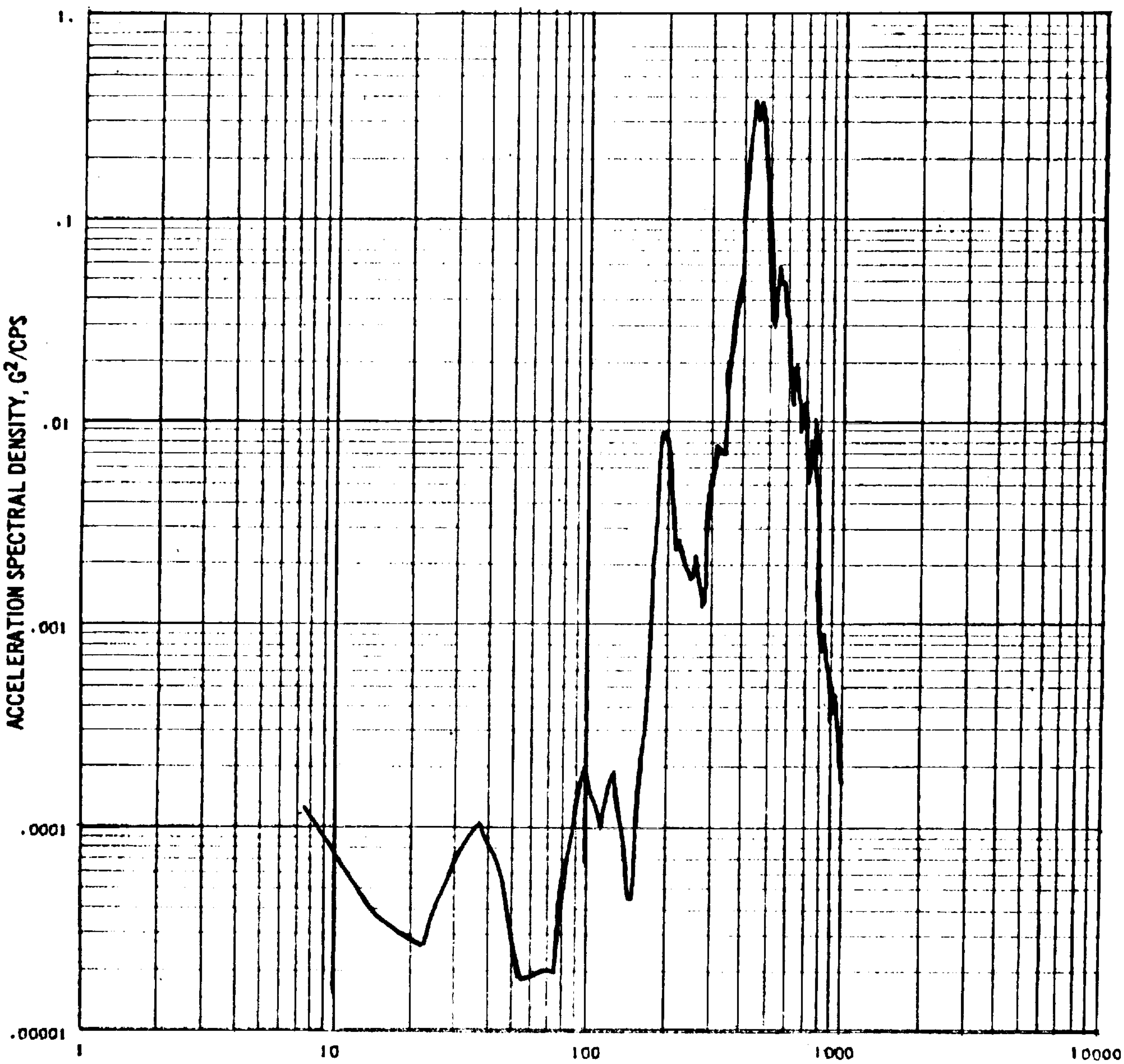


FIGURE 24 C

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/ASSET, DSV-2F

(STATION 141)

PERIOD OF MAXIMUM VIBRATION (T + 60 SECONDS)

RADIAL AXIS

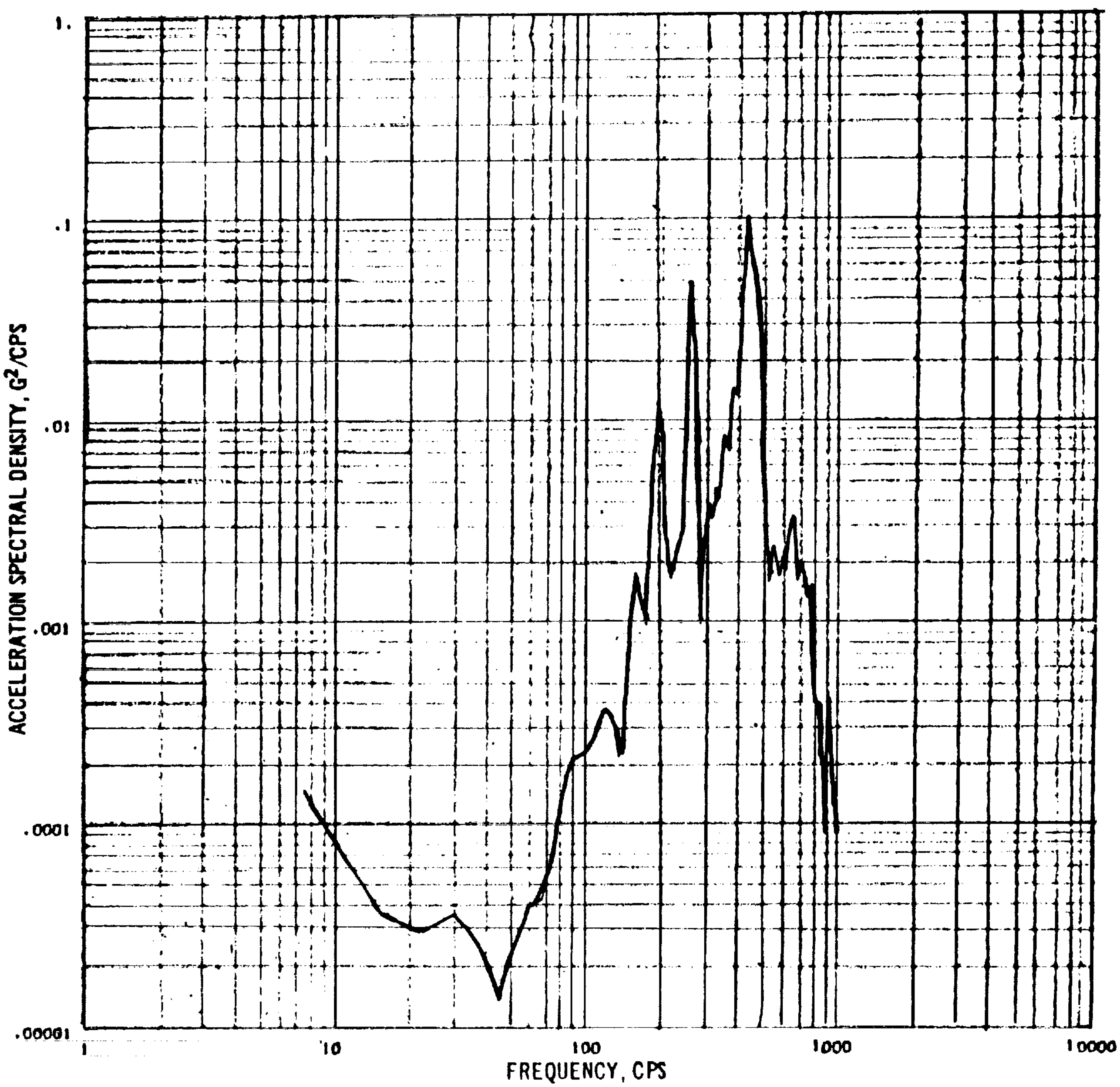


FIGURE 24 d

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/DELTA ASSET, DSV-2G, BOOSTER S/N 240
FIRST STAGE (STATION 130)
LIFTOFF PERIOD
RADIAL AXIS

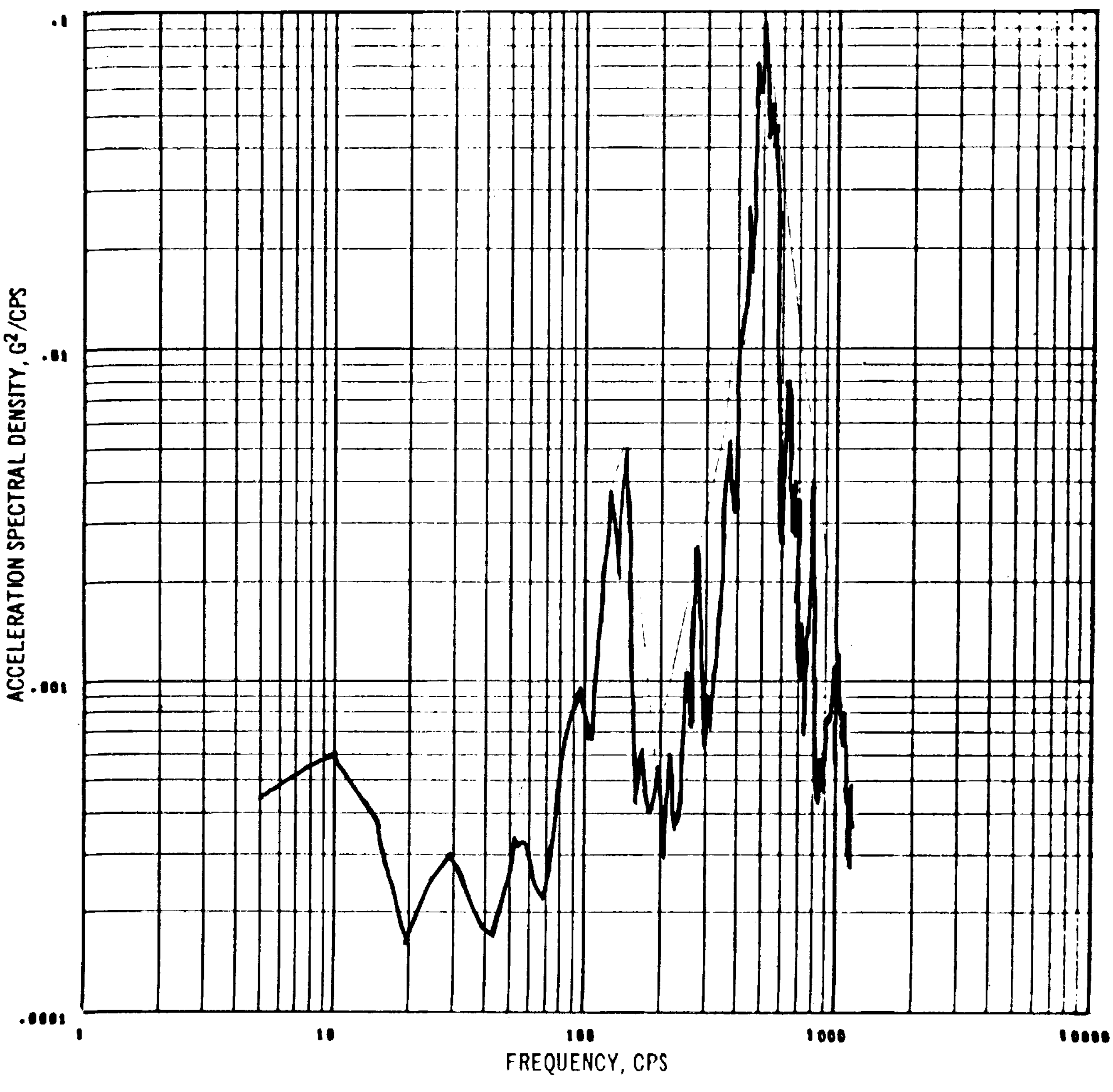


FIGURE 25 a

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240

FIRST STAGE (STATION 130)

PERIOD OF MAXIMUM VIBRATION (T + 59 SECONDS)

THRUST AXIS

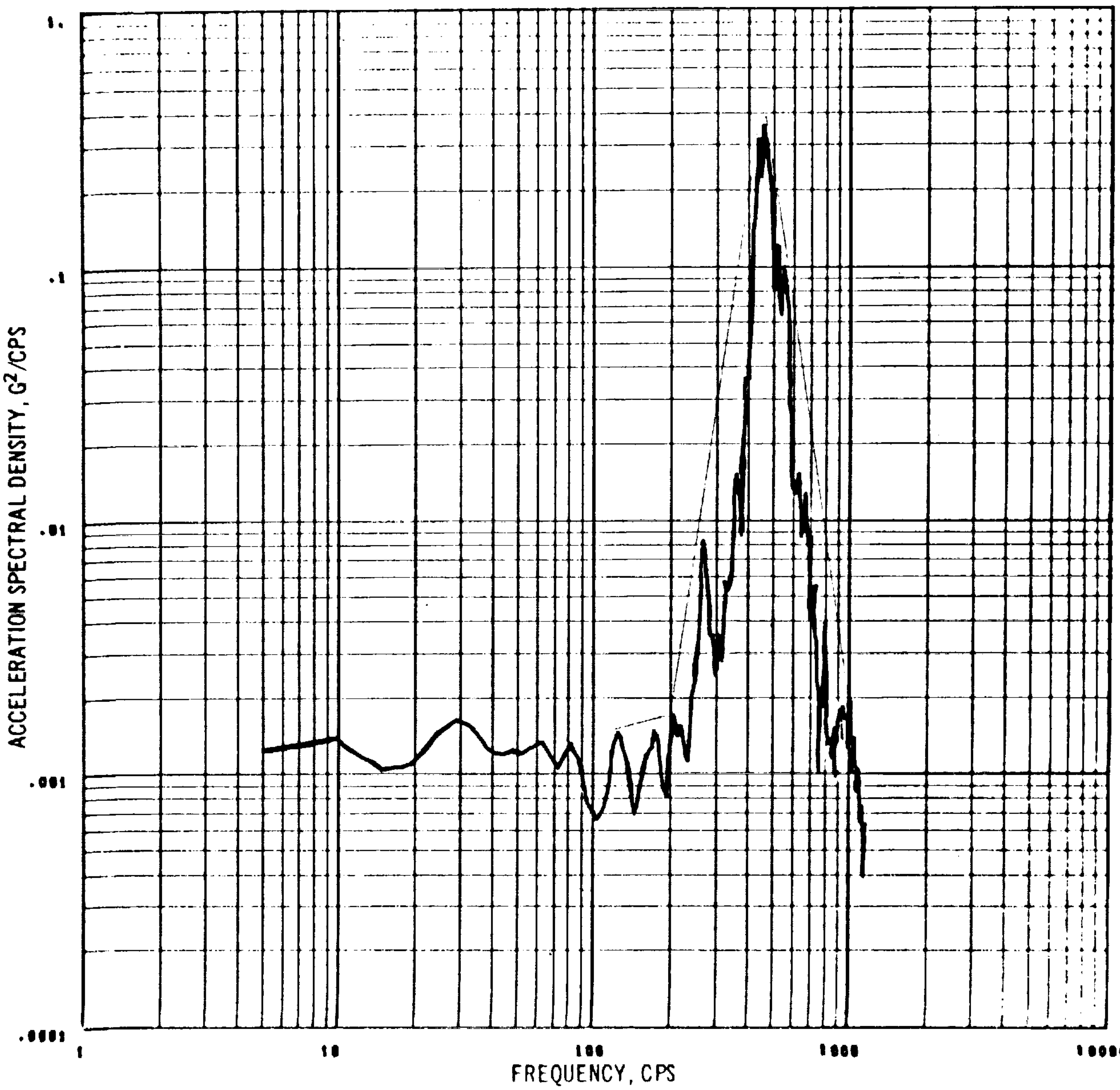


FIGURE 25 b

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
FIRST STAGE (STATION 130)
PERIOD OF MAXIMUM VIBRATION (T + 59 SECONDS)
RADIAL AXIS

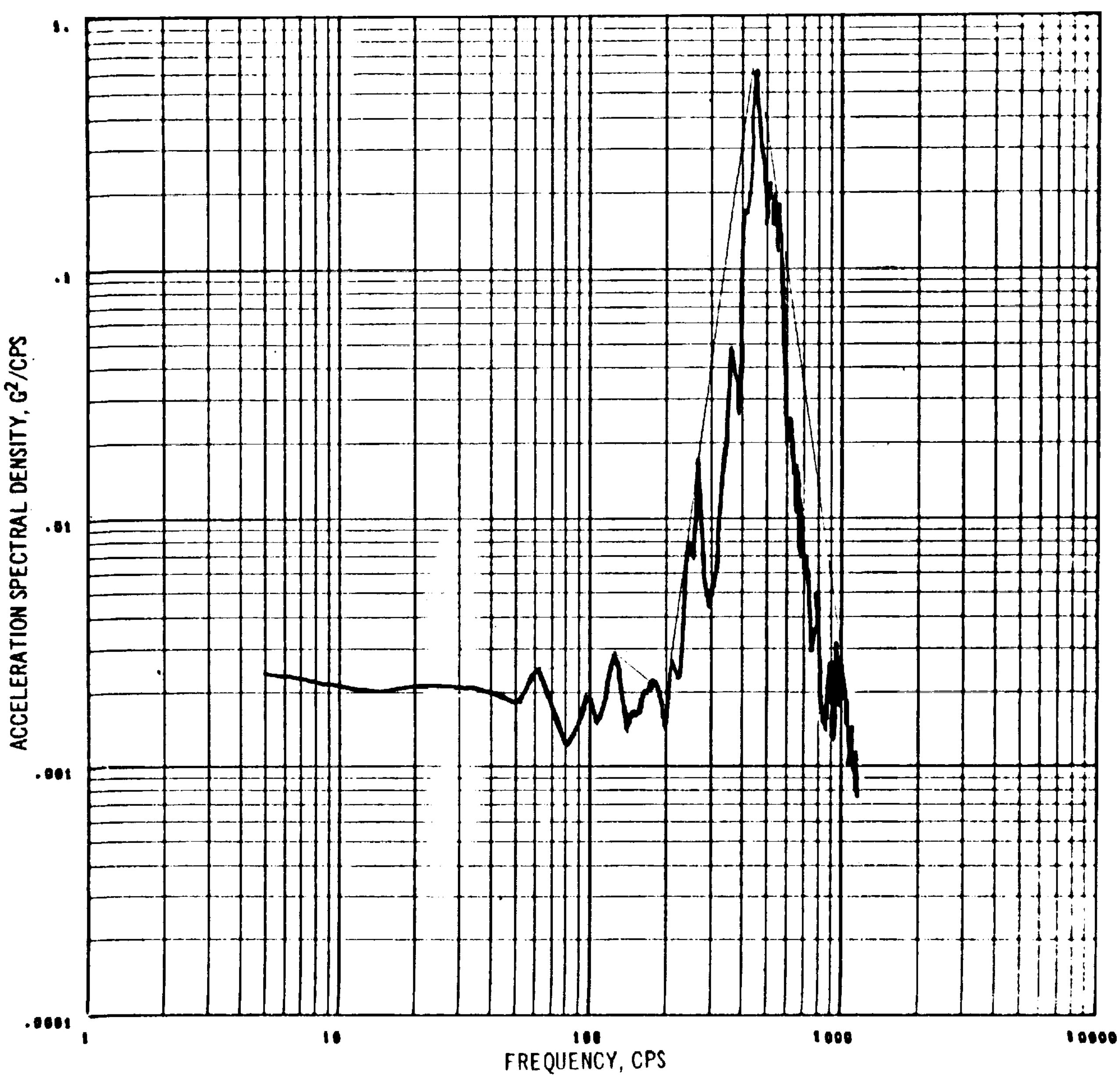


FIGURE 25C

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
SECOND STAGE (STATION – 150)
LIFTOFF
THRUST AXIS

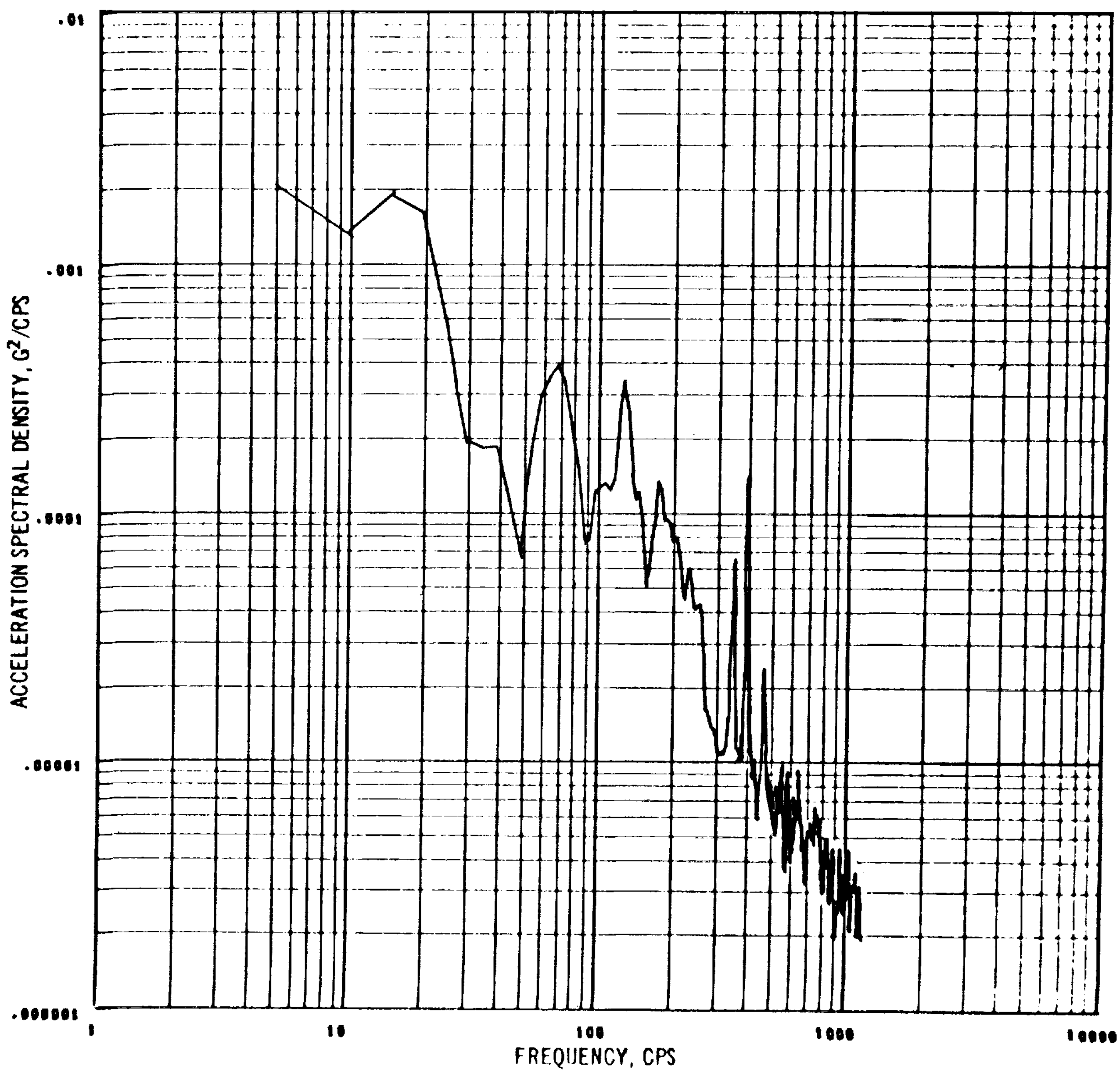


FIGURE 26 a

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
SECOND STAGE (STATION – 150)
PERIOD OF MAXIMUM VIBRATION (T + 59 SECONDS)
THRUST AXIS

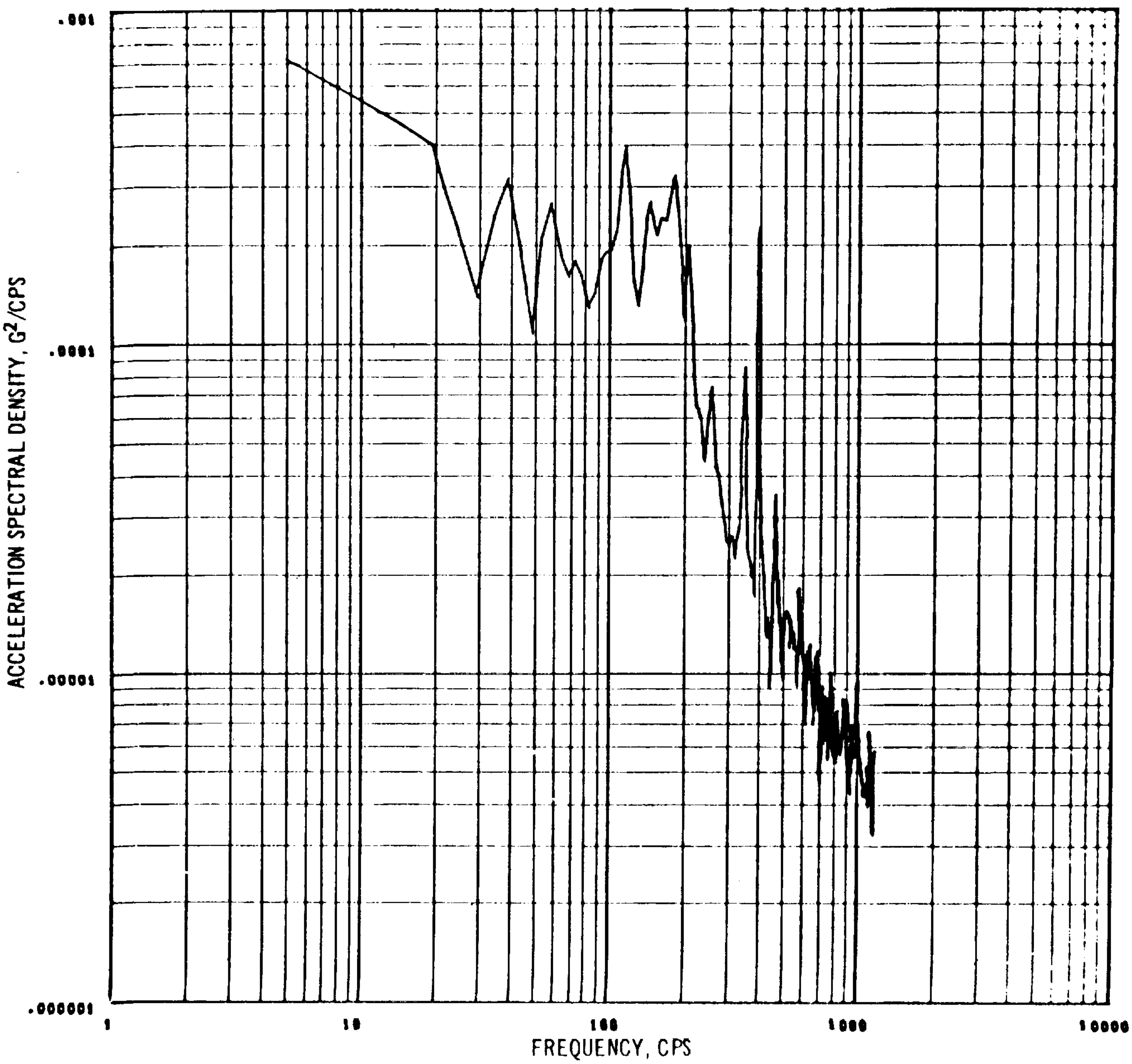


FIGURE 26 b

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
SECOND STAGE (STATION – 150)
PERIOD OF MAXIMUM VIBRATION (T + 61 SECONDS)
RADIAL AXIS

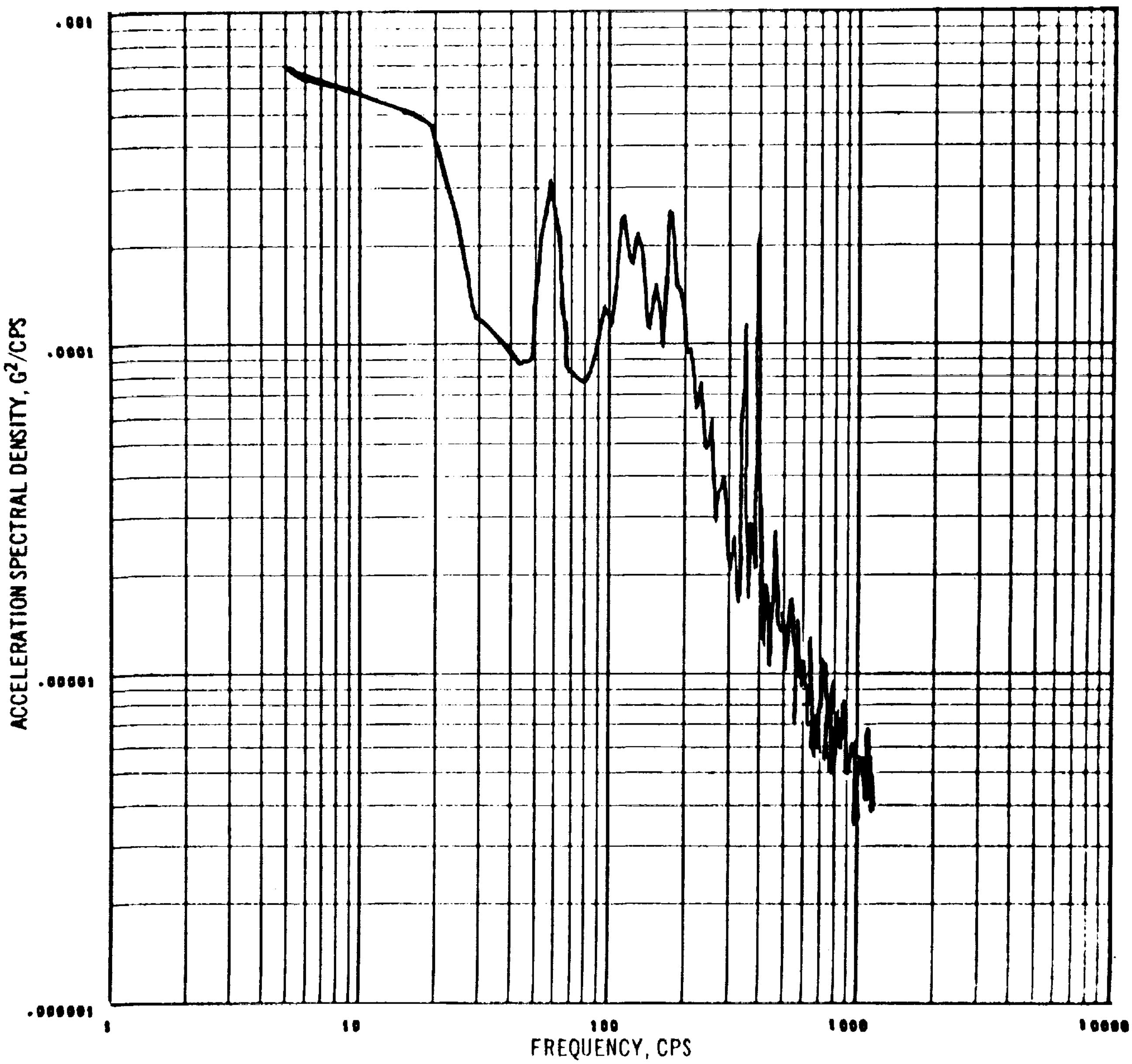


FIGURE 26 C

ACCELERATION SPECTRAL DENSITY ANALYSIS
THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
ASSET/ADAPTER INTERFACE
LIFTOFF PERIOD
THRUST AXIS

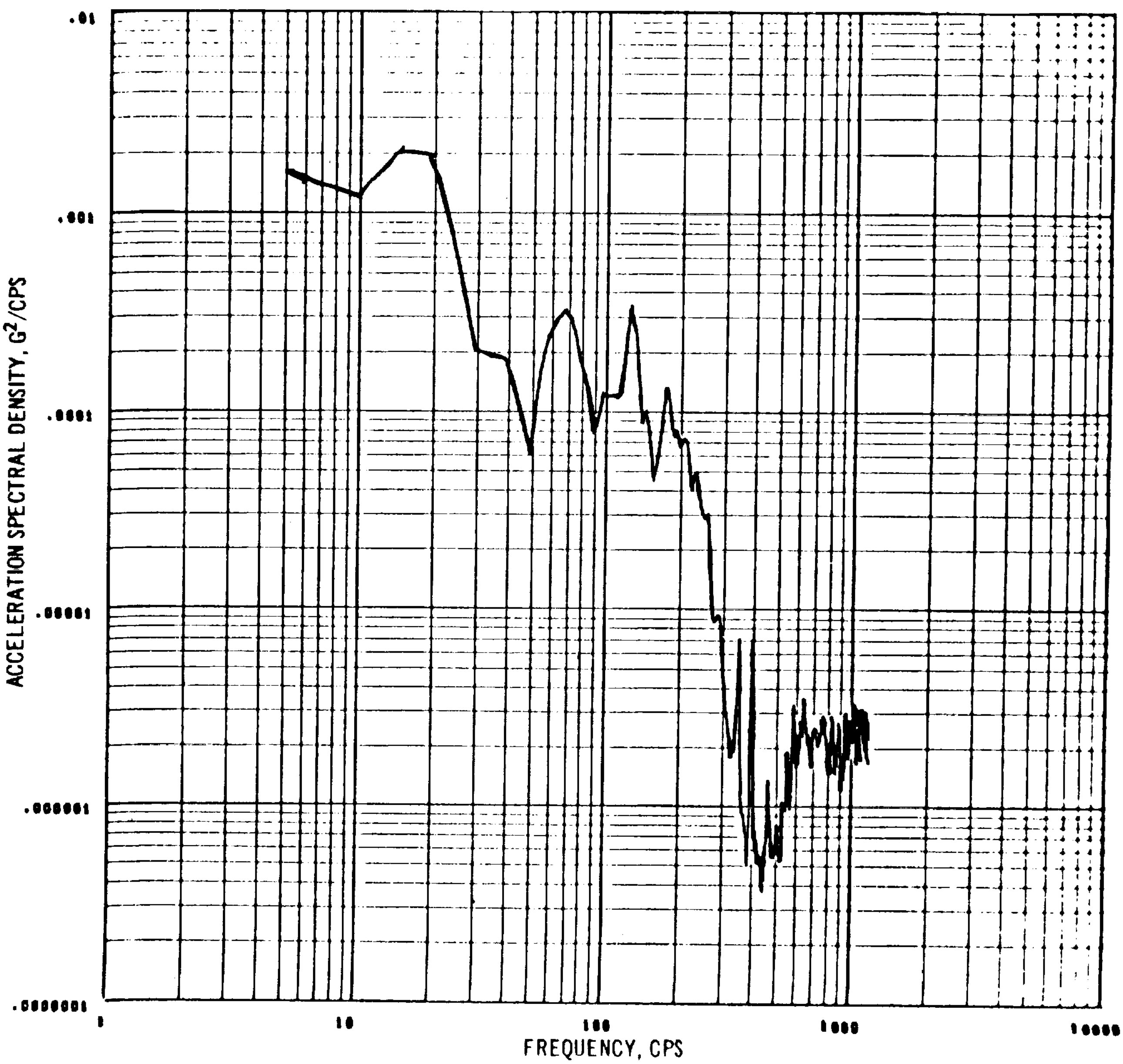


FIGURE 27 a

ACCELERATION SPECTRAL DENSITY ANALYSIS

THOR/DELTA/ASSET, DSV-2G, BOOSTER S/N 240
ASSET/ADAPTER INTERFACE
PERIOD OF MAXIMUM VIBRATION (T + 59 SECONDS)
THRUST AXIS

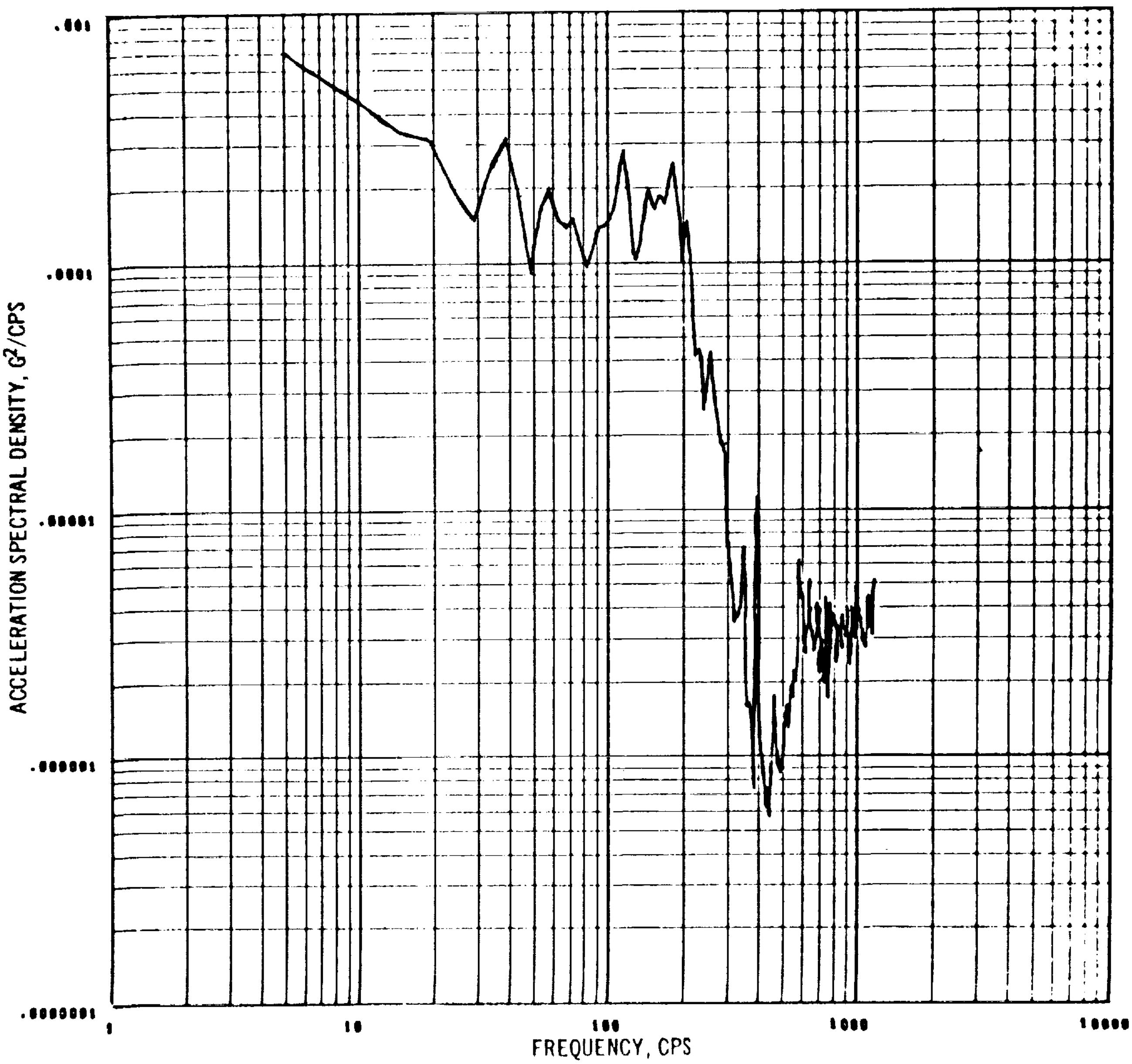


FIGURE 27 b

NASA-Langley, 1965 CR-196